

**THE IMPACT OF MULTIPLE EMISSION
REGULATIONS ON INCOME, OUTPUT,
AND EMPLOYMENT IN
OKLAHOMA**

By

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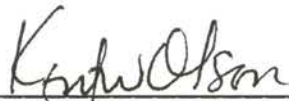
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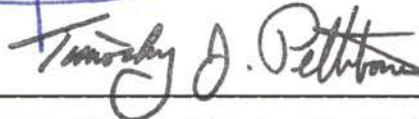
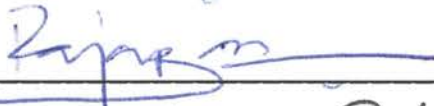
**Submitted to the Faculty of the
Graduate College at
Oklahoma State University
In partial fulfillment of
the requirements for
the Degree of
Doctor Of Philosophy
August 2003**

THE IMPACT OF MULTIPLE EMISSION
REGULATIONS ON INCOME, OUTPUT,
AND EMPLOYMENT IN
OKLAHOMA

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ACKNOWLEDGMENTS

I wish to express my deepest gratitude to the chairman of my committee, Dr. Kent Olson for his continuous guidance, patience, and encouragement throughout my participation in the Ph.D. process. Dr. Olson's invaluable advice helped me stay the course and helped guide me to my goal of completing this dissertation and my Ph.D. program. Without his help the preparation and completion of this dissertation would not have been possible.

I would also like to express my sincere appreciation to members of my Advisory Committee: Dr. Keith Willett, Dr. Raja Basu, and Dr. Will Focht for their timely advice, assistance, suggestions, and for the confidence that they had in me to succeed. My committee motivated me to do my best and for this I am eternally grateful.

In addition, the author would also like to express his appreciation to Mr. Paul Kondis, in the Energy Information Administration's Washington D.C. office for his assistance in helping me obtain critical documents for support of my research.

Finally, a special thank you goes to my family, especially my parents, Dale and Ruth Delano for their encouragement and support. Also, most deserving of acknowledgement and appreciation is my wife, Susie who has been a source of constant inspiration and motivation for me to complete my Ph.D. program.

Words are inadequate to describe the support and confidence that she has given me throughout the completion of this program. Susie graciously accepted responsibilities that should have been mine.

One cannot achieve their goals without the interaction and help of others. To my family, members of my committee, and friends, I wish to again say thank you and may God Bless you all.

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CHAPTER I

INTRODUCTION

Need for the Study

Over the next decade, power plants may face significant reduction requirements for emissions of sulfur dioxide (SO₂) and nitrogen oxides (NO_x) even beyond the levels called for in the Clean Air Act Amendments of 1990. In addition, these power plants could also face requirements to reduce mercury (Hg) and carbon dioxide (CO₂) emissions. Several proposed bills in Congress have targeted reduction of these four emissions.¹

Because the Environmental Protection Agency's (EPA) Acid Rain Program has worked so well in reducing emissions via a cap and allowance trading program, in particular for SO₂ emissions, Congress has asked EPA and the Energy Information Administration (EIA) to determine the impacts of various scenarios with alternative power sector emission caps regarding NO_x, SO₂, and Hg. They have also asked EIA to assess the impact from reducing CO₂ emissions that occur beyond the level expected in 2007. It is anticipated that a carbon-trading program would be very costly; the potential transfer of wealth within the economy under a carbon-trading program is tremendous and is likely to far outstrip the magnitude of any previous

¹ Energy Information Administration, "Reducing Emissions of Sulfur Dioxide, Nitrogen Oxides, and Mercury from Electric Power Plants," <http://www.eia.doe.gov.html>. (September 2001).

trading program.² Even so, it is assumed that the emission reduction programs will be patterned after the SO₂ emissions trading program and will include emission allowances for each pollutant totaling to the specified limit for each emission.

Because the timing and levels of emission reduction requirements under the proposed multiple regulatory standards are uncertain, compliance planning is somewhat complicated. It can take many years to design, license, and construct new electric power plants and emission control equipment, which could then be in operation 30 years or longer. As a result, power plant operators need to look into the future to evaluate the economics of new investment decisions.³

EIA has analyzed the costs and impacts of a set of emission control limits for electricity generators under two different scenarios, which include both reference and advanced technology cases which have been analyzed with and without the proposed emission limits for each case. The projections and quantitative analysis used to determine the impacts of these various scenarios were prepared using the National Energy Modeling System (NEMS), an energy-economy model of U.S. energy markets designed, developed, and maintained by EIA. The Energy Information Administration is the independent statistical and analytical agency within the Department of Energy.

This dissertation uses the results of the National Energy Modeling System effort as the most likely national outcome of adopting the new regulations.

² Dallas Burtraw, Resources, "Carbon Emission Trading Costs and Allowance Allocations: Evaluating the Options," Fall 2001.

³ Energy Information Administration, "Annual Energy Outlook 2002, With Projections to 2020," DOE/EIA-0383 (December 2001).

According to this effort, the adoption of the proposed regulations will substantially increase the costs of compliance, raise the price of electricity, and reduce overall electricity consumption. It is hard to imagine any state escaping this fate. Within the electricity producing sector, however, there will be a significant substitution of natural gas for coal as a primary energy fuel. This should provide a positive boost to the Oklahoma economy, given Oklahoma's position as a major producer of natural gas.

The objective of this dissertation is to determine if the net impact of the new proposed regulations on the Oklahoma economy are likely to be positive or negative. The studies using NEMS do not in fact, provide an answer to this problem; NEMS does not produce state-specific impacts. The national impacts from NEMS will be linked to the Oklahoma economy by way of a bridge model that determines the primary (direct) impact on utility construction for coal, natural gas, petroleum, and renewables plants, electricity generation by fuel types, end-use demand, and the production of pollution control equipment in Oklahoma. The primary impacts in Oklahoma will generate secondary impacts on income, employment, and output that will be determined using the IMPLAN input-output model for Oklahoma.

It should be noted this study does not take into account benefits, both actual and perceived, that could come from the human health and environmental side of the equation. Instead, this study focuses on the actual costs and derived benefits, both positive and negative, based on implementing the proposed multiple emission regulations.

Expected results from this study should find that electricity prices will increase while the total demand for electricity should decrease. Therefore, Oklahoma income, employment, and output should decrease. On the other hand, Oklahoma's production of natural gas should increase and therefore, have a positive effect on the Oklahoma economy. In addition, an increase in Oklahoma's market share of pollution control equipment should be anticipated, which would also have a positive effect on the Oklahoma economy. In theory, the total net effect on the Oklahoma economy is unknown, underscoring the need for this study.

Literature Review

Many studies and modeling efforts have been done regarding energy and fuel forecasting. In fact, a number of studies have been done that estimate how fuel prices will affect electricity prices and what the effects will be on the economy. There are various models on the market that estimate these effects. However, there are fewer studies that have estimated the effects of multiple emission regulations on fuel prices and how these regulations impact state economies.

At the time of this writing, all multiple emission based regulations scenarios involve some type of an emissions trading scheme. They provide a market driven approach to solving emission problems versus the old command and control philosophy. This approach is proving to be quite capable of reducing pollutants from the environment.

In 1996, Klaassen suggested that potential cost savings of emission trading compared with command-and-control types are large and if an environmental agency retains perfect information on costs, then emission permit trading may be more cost efficient than command-and-control solutions for meeting a set of standards.⁴

The literature points to the fact that different emission trading schemes based on current regulations saved costs, did not impair environmental quality, had little or an unknown impact on innovation, and required more administration than regulation.

EPA evaluates its emissions based regulations based on reductions that have been achieved and estimates the impact those reductions have had on human health and the environment. For example, Phase I results from the Acid Rain Program show that SO₂ emission reductions have produced measurable environmental improvements. Wet sulfate (SO₄) deposition levels (a primary component of acid rain) have dropped as much as 25 percent in the eastern United States.⁵

By 2010, the Acid Rain Program is expected to have achieved a 50 percent reduction in electric utility emissions of SO₂ based on 1980 levels. Without the Acid Rain Program, projected SO₂ emissions would exceed 103

⁴ Ger Klaassen, "Acid Rain and Environmental Degradation," International Institute for Applied Systems Analysis, 1996.

⁵ Environmental Protection Agency, "EPA's Acid Rain Program: Results of Phase I – Outlook for phase II," <http://www.epa.gov/airmarkets> (October 2001).

percent of the 1980 levels that would have a greater negative impact on human health and the environment.

The Department of Energy's (DOE) Energy Information Administration reviews key energy issues and feeds these key issues into a model that forecasts annual energy projections. The model attempts to predict economic growth, energy prices, energy consumption, energy intensity, electricity generation, energy production and imports, and carbon dioxide emissions.⁶ This model estimates the annual energy outlook for 2002 with projections to 2020.

The Electric Power Research Institute (EPRI) researches topics that will have an affect on the electric utility market. Funded by U.S. utility companies, EPRI forecasts energy prices, supports technology innovation, and reviews the impact from regulations and how those regulations will impact fuel supplies needed for production of electricity. For instance, one research project was devoted to SO₂ compliance and allowance trading and projected developments that would result from such trading. The objective of the report was to evaluate recent and future emission compliance costs and markets for fuels, technology, and allowances in order to lay out the range of possible outcomes and what it would take to produce them. The research consisted of a survey of opinions, advice, and questions expressed by individuals in the utility, fuel supply, allowance trading, academic, regulatory, and consulting communities.⁷

⁶ U.S. Department of Energy: Energy Information Administration, "Annual Energy Outlook 2002 with Projections to 2020," <http://www.eia.doe.gov/oiaf/aeo/index.html>. (December 2001).

⁷ Electric Power Research Institute, "SO₂ Compliance and Allowance Trading: Developments and Outlook," <http://www.epri.com>. (April 1997).

Resources For the Future, is an institutional think tank that researches various environmental and energy projects and helps facilitate regulatory design and policy formation. One such project is the development of the Tracking and Analysis Framework (TAF) used for monitoring sulfur and nitrogen oxide emissions from power plants. The Tracking and Analysis Framework is an integrated assessment model that was developed for the National Acid Precipitation Assessment Program (NAPAP) that tracks and assesses the economic and environmental effects of changes in sulfur oxide and nitrogen oxide emissions from power plants that burn fossil fuels in North America.⁸ This project focuses on the effects of emission trading, the major regulatory innovation introduced in the Title IV of the Clean Air Act. However, none of these studies attempted to address the net economic impact on income and employment that might result from such regulations.

This research attempts to shed additional information on previous work that has been done on the economic impact of multiple emissions based regulations. This research aims to measure the impact from SO₂, NO_x, Hg, and CO₂ based regulations at the state level, specifically on Oklahoma's economy. Studies reviewed to date, do not focus on the impact at the state level. These studies primarily look at impacts of multiple emission regulations from a national viewpoint. This research will bridge the multiple emission regulation data from NEMS to an Implan model to study the impact on the Oklahoma economy. Finally, this research will use the input-output framework to study the net impact

⁸ Research For the Future, "Development of the Tracking and Analysis Framework," http://www.rff.org/project_summaries/files/krupnick_taf.htm. (December 1996).

of multiple emissions based regulations on income, output, and employment in Oklahoma. Many of the earlier studies that review impacts from multiple emission regulations do so from the standpoint of reduced emissions and the impact that those reduced emissions have on human health and the environment. The impact of reduced emissions and compliance costs thereof, is not a total indicator of how much of an impact the regulations have on the economy. For example, compliance costs for reducing multiple emissions could be offset by the creation and expansion of an emissions trading industry in Oklahoma. It could also mean additional increases in natural gas production. Therefore, this study will attempt to answer the question of the overall impact of multiple emission regulations from the state's income, output, and employment outlook.

Objective

The objective of this dissertation is to determine if the net impact of the new regulations on the Oklahoma economy are likely to be positive or negative. The studies using NEMS do not in fact, provide an answer to this problem; NEMS does not produce state-specific impacts. The national impacts from NEMS will be linked to the Oklahoma economy via a bridge model that determines the primary (direct) impact on electricity prices and consumption, electric power production, natural gas production, and the production of pollution control equipment in Oklahoma. The primary impacts in Oklahoma will generate

secondary impacts on income, output, and employment that will be determined using the IMPLAN input-output model for Oklahoma.

Structure of the Dissertation

This study consists of six chapters, as follows:

- I. Introduction
- II. Proposed Regulations
- III. Energy Information Administration's Model, Analysis, and Results
- IV. Oklahoma Bridge Model
- V. Input/Output Analysis for Oklahoma
- VI. Conclusions/Recommendations

CHAPTER II

PROPOSED REGULATIONS

Introduction

The United States Congress is considering implementing a multiple emissions reduction plan for all power plants in the U.S. Congress has requested that EIA analyze the potential impact of alternative plans in the context of prospective technology improvements and other market-based opportunities. The four-targeted emissions are: sulfur dioxide (SO₂), nitrogen oxides (NO_x), mercury (Hg), and carbon dioxide (CO₂). Using 2002 as a start date for emissions reduction, the request specifies that by 2007 NO_x emissions from electricity generators are to be reduced to 75 percent below 1997 levels, SO₂ emissions to 75 percent below the full implementation of the Phase II requirements under Title IV of the Clean Air Act Amendments of 1990 (CAAA90), Hg emissions to 90 percent below 1999 levels, and CO₂ emissions to 1990 levels. It is assumed that these emissions limits are applied to all electricity generators, excluding cogenerators.⁹

Up to now, each of these pollutants has been addressed through separate regulatory programs, many of which are going through a modification process. For example, to control acidification, the CAAA90 has required operators of electric power plants to reduce emissions of SO₂ and NO_x. Because SO₂ and NO_x contribute to the formation of regional haze, states could require that these

⁹ Environmental Protection Agency: Office of Air and Radiation, "Economic Analysis of a Multi-Emissions Strategy," <http://www.epa.gov/airmarkets/html>.

emissions be reduced below current regulations in order to improve visibility in some areas. Also, the EPA decided in December 2000 that mercury emissions needed to be reduced. Proposed regulations for Hg will be developed over the next three years, and will probably be included as part of a multiple emissions reduction strategy. Further, if the United States decides that greenhouse gas emissions need to be reduced, it is likely that energy-related CO₂ emissions will need to be addressed.

The Congress is aware that there are potentially significant impacts from adopting the prospective regulations, but they do not have the kind of model in-house that is required to determine these impacts. Outside Congress, there are three models capable of handling such a task: EPA's Clean Air Power Initiative (CAPI), the Tracking and Analysis Framework (TAF) developed jointly by Lawrence Livermore Laboratory and Resources For the Future, and the EIA's National Energy Modeling System (NEMS).

The objective of the Clean Air Power Initiative is to develop, with stakeholder participation, an integrated regulatory strategy for major pollutants that are emitted from electric generating plants. These major pollutants include: sulfur dioxide, nitrogen oxides, and mercury, all of which contribute to a variety of human health and environmental problems. The Clean Air Act Amendments of 1990 contain various requirements that have and will continue to affect the electric power generating industry well into the future. The Clean Air Power Initiative primarily focuses on sulfur dioxide and nitrogen oxides because EPA has direct authority to regulate these pollutants and because these pollutants

contribute to the formation of ground-level ozone, which causes reduced pulmonary function and crop damage. Finally, CAPI is a modeling tool that continues to be developed for testing various scenarios and sensitivity cases, explore economic and environmental impacts, and to provide input to the Clean Air Act Advisory Committee deliberations.

TAF is an integrated assessment model that was developed for the National Acid Precipitation Assessment Program (NAPAP). The integrated modeling framework is intended as an aid in assessing, informing, and guiding U.S. regulatory policies that deal with targeted emissions. This model tracks and assesses economic impacts and environmental effects of changes in sulfur dioxide and nitrogen oxide emissions from electric generating plants that burn fossil fuels. Of particular interest to researchers are the long-term effects from emission trading. Using this model, several predefined scenarios, combinations of a base regulatory case and a comparison case, can be compared. This model allows for increased flexibility and speed in analyzing alternative scenarios and forecasts. The major problem with using TAF is that it does not address state impacts and it requires the researcher to supply information on critical inputs that would require a major research effort by itself.

Although either CAPI or TAF could have been used to analyze the impacts of tighter emissions limits, NEMS was used instead, primarily because the outputs of NEMS can be used directly to determine state-level impacts. NEMS is a fully integrated framework that captures the interactions of energy supply, demand, and prices across all fuels and all sectors of U.S. energy markets. The

modules within NEMS interact to solve for the economic supply and demand balance for each fuel type. NEMS projections are through 2020, and include production, imports, conversion, consumption, and energy prices. The model focuses on regional activity in order to capture regional differences in energy consumption patterns and resource availability. The model incorporates interactions between the energy system and the economy and between domestic and world oil markets. The changes in energy prices and energy activity affect economic activity and this feedback is captured within the NEMS model.

Another key feature of NEMS is the representation of technology and its improvement over time. Explicit treatments of individual technologies and their characteristics, such as capital cost, operating cost, date of commercial availability, efficiency, and other characteristics are all analyzed within the model. In addition, NEMS captures the most significant factors that influence the turnover of energy-using and producing equipment and the choice of new technologies.

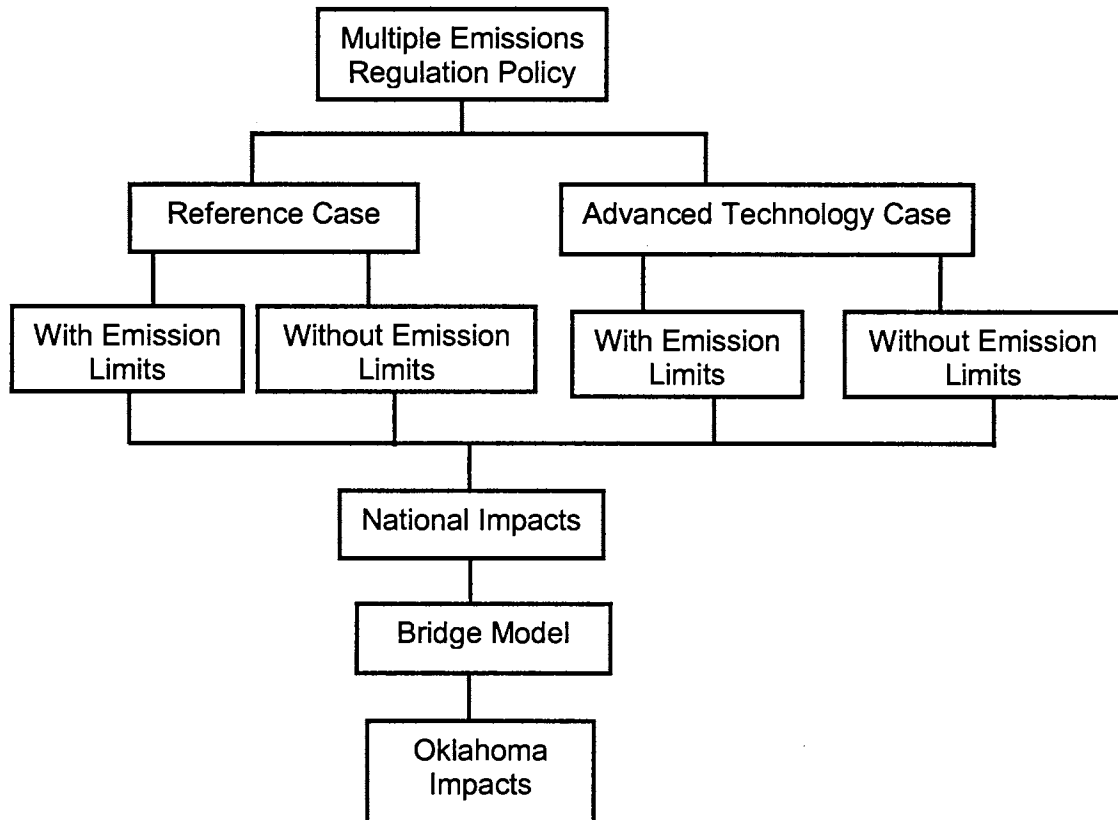
The impacts of the proposed federal emission limits have been analyzed by the EIA using NEMS in the context of two scenarios:

- The Energy Information Administration's Standard or Reference Case Scenario, and
- The Energy Information Administration's Advanced Technology Scenario, which assumes earlier introduction of promising technologies, lower costs, higher maximum market potential, and higher efficiencies than the Standard or Reference Scenario.

A breakdown of the two scenarios to be analyzed is highlighted in the impact flowchart, Figure 2.1.

FIGURE 2.1

Impact Flow Chart



For both cases with emission limits, the resource costs are projected to be higher with respect to the resource costs in the comparable cases without emission limits. The largest increase is for fuels used in the generation of electricity. In addition, there will be additional costs associated with purchases of

power from other generators and capital costs for retrofitting plants with state of the art emission control equipment and/or new generating facilities.¹⁰

Overall, the emissions limits are achieved via miscellaneous reductions in energy demand, a decrease in coal-fired electricity generation and an increase in natural gas, nuclear, and renewable electricity generation. This overall emissions reduction will also include installation of additional emissions control equipment. Economical technologies to capture and reduce CO₂ are considered unlikely due to the timeframe used in the analysis.

It should be noted that this analysis excludes several potential environmental actions, such as new regulations that address regional haze. States are in the process of developing implementation plans that will deal with regional haze. Another environmental action would concern the possible ratification of the Kyoto Protocol primarily designed to control and reduce carbon dioxide emissions. In addition, no effect is made to review the outcome of ongoing studies to reduce mercury emissions from electric power plants.

Reference Case: Impact Without Emission Limits

The reference case for this analysis already includes limits for sulfur dioxide and nitrogen oxides that were enacted under the Clean Air Act Amendments of 1990 (CAAA90).¹¹

¹⁰ Energy Information Administration, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants with Advanced Technology Scenarios," SR/OIAF/2001-05 (October 2001).

¹¹ Energy Information Administration, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard," SR/OIAF/2001-03 (July 2001).

Under this scenario where additional emission limits are not adopted, impacts from an emissions standpoint would be minimal. Sulfur dioxide would be capped at 8.95 million tons per year as per the CAAA90. Emissions of nitrogen oxides would continue to increase, but at a much slower rate versus previous years. More stringent NO_x emissions reductions are required under a number of Federal and State laws that have either taken effect or will take effect between 1997 and 2004. In addition, States are beginning to address visibility problems (regional haze) in different parts of the country. In some areas, States could require that those emissions be reduced systematically to improve visibility. Mercury emissions would not be capped, but would be reduced to some degree because of the emission control equipment that is required for SO₂ and NO_x reductions. Carbon dioxide emissions would not be capped and should continue to increase.

In the reference case without emission limits, total energy consumption is anticipated to increase yearly between 1999 and 2020, at an average annual rate of 1.4 percent, reaching 128 quadrillion British thermal units (Btu). These numbers are based on a projected economic growth rate of 3.0 percent per year. The energy intensity of the economy, measured as energy use per dollar of real gross domestic product (GDP) is anticipated to decline at an average annual rate of 1.6 percent. This is due in part to anticipated efficiency improvements in the

use of energy and a shift in the economy from more energy-intensive industries.¹²

Reference Case: Impact With Emission Limits

If the proposed emission limits become law, then between 2002 and 2007 the goal would be to reduce NO_x emissions from electric generating facilities to seventy-five percent below 1997 levels (from 6.191 to 1.548 million tons per year), SO₂ emissions to seventy-five percent below the required levels of the Clean Air Act Amendments of 1990 (from 8.950 to 2.240 million tons per year), Hg emissions to ninety percent below 1999 levels (from 43.3 to 4.3 tons per year), and CO₂ emissions to 1990 levels (475 million metric tons carbon equivalent per year).

When the emission limits are applied to the reference case discussed above, it projects that the average price of electricity in 2020 will cost thirty three percent more than the reference case without emission limits due to the cost to electricity generators of meeting the imposed emission limits. Because of the higher energy prices, total energy consumption is anticipated to be reduced by approximately seven quadrillion British thermal (Btu) units by 2020.

With the added emission limits, coal and electricity consumption is expected to be lower than in the reference case without emission limits. As power plants reduce their coal usage, the projected use of existing nuclear power plants, natural gas, and renewables is expected to increase, causing the

¹² Energy Information Administration, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants with Advanced Technology Scenarios," SR/OIAF/2001-05 (October 2001).

consumption of these energy sources to increase. Prices are expected to increase because the cost of producing electricity with emission limits will be more costly than without emission limits. Other increased costs associated with this scenario include additional costs for increased use of pollution control equipment, transactions costs of trading emissions permits, and higher costs for fuels used to generate electricity.

Anticipated higher electricity prices will cause end users to reduce their consumption of electricity. Over time, the increased use of natural gas should have an impact on the higher electric prices moderating price increases and eventually stabilizing the price of electricity.

In this study, for all cases with emission limits, the resource costs are anticipated to be higher relative to the resource costs in the cases without emission limits. The greatest cost increase is associated with fuels used to generate electricity. In addition, there are investment costs for new power plant facilities and for retrofitting existing power plants with improved emission control equipment. Also, there are costs associated with purchases of power from other power plant generators.

Advanced Technology Case: Impact Without Emission Limits

This case assumes continued improvements in technology will be made for both energy consumption and production even without additional emission limits being added to the mix. Technology winners will be chosen based primarily on costs and customer choice over competing technologies.

Technology progress related to the oil and gas sector for exploration and production events are represented by yearly improvements in finding rates, drilling, success rates, and operating costs compared with historical trends. Technology advancements in exploration and production include such things as three-dimensional seismology and horizontal drilling. Technology advancements for the coal sector include such things as improvements in coal haulage systems at underground mines.

Due to rapid technology development in the advanced technology case without emission limits, total energy consumption is anticipated to decrease by 6 percent when compared to the reference case without limits. This is primarily due to a quicker adoption of more efficient technologies in the end use demand sectors.

An increase is anticipated in the use of existing nuclear power and renewable technologies due to cost and performance advancements. Consumption of all fossil fuels and electricity is expected to be lower when compared to the reference case.

Advanced Technology Case: Impact With Emission Limits

By 2020, the average delivered price of electricity is anticipated to be 22 percent greater in the advanced technology case with emission limits as compared to the same case without emission limits. This 22 percent increase in the price of electricity in 2020 results from reducing emissions of SO₂, NO_x, Hg, and CO₂. These emissions reductions are achieved partly by changes in the fuel mix used by power plants to generate electricity. Because of the projected

higher energy prices, total energy consumption is anticipated to decrease by 4 percent in 2020 relative to the advanced technology case without emission limits. In addition, energy expenditures are expected to be higher.

Total projected consumption of coal and electricity should be lower compared to the advanced technology case without limits. However, the anticipated consumption of natural gas, nuclear power, and renewables are expected to be higher as power plant generators move from using coal to increasing their use of existing nuclear power, more natural gas, and an increase in renewable generation via advanced technologies. Projected CO₂ emissions in 2020 are anticipated to be lower by 12 percent compared to the advanced technology case without limits, because of reduced energy consumption and the move to a different fuel makeup of more natural gas, renewables, and nuclear power.

Because of the anticipated higher electricity prices, consumers are expected to reduce consumption by 7 percent in 2020, compared to the advanced technology case without limits.

Under this scenario, it is anticipated that power producers will need to purchase additional allowance permits. In addition, electricity generators are also expected to increase their investments in pollution control equipment in order to reduce emissions of SO₂, NO_x, Hg, and possibly CO₂.

Impact on Energy Markets From Advanced Technology

Based on projections of the more rapid assumed technology development, total energy consumption in 2020 is anticipated to be reduced by 6 percent compared to the reference case, because more efficient technologies would be adopted sooner.

The primary energy intensity is anticipated to decline at an average yearly rate of 1.9 percent between 1999 and 2020, compared to 1.6 percent for the reference case. In addition, it is anticipated that fossil fuels and electricity consumption will be lower when compared to the reference case, in part because the use of existing nuclear power and renewable technologies is greater due to the assumed cost and performance improvements. CO₂ emissions in 2020 are anticipated to be reduced by 8 percent compared to the reference case, because of the shift in the fuel mix to more nuclear power and renewables and because of a reduction in energy consumption. Also, prices for both natural gas and coal are anticipated to be lower in the advanced technology case when compared to the reference case. This reduction is primarily due to accelerated technology development. As a result of these expected lower prices and demand, energy expenditures should also be lower.¹³

¹³ Energy Information Administration, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants with Advanced Technology Scenarios," SR/OIAF/2001-05 (October 2001).

Macroeconomic Impacts

Additional legislated emission limits on electric power producers will affect the United States economy via increased energy prices. In the past, forecasters have acknowledged that higher energy prices can become a burden on the overall economy. Historical events show that a downward adjustment in the growth of economic activity will be the rule and not the exception as energy prices rise. Higher energy prices will affect prices of other goods and services.¹⁴ Higher energy costs will result in a reduced use of energy therefore shifting production toward less energy intensive sectors and encouraging energy conservation. In addition, increased energy prices would raise non-energy intermediate and final product prices, which in turn would bring about cyclical behavior in the economy. This condition in the economy would cause output and employment losses in the short term, but the economy would be expected to rebound and move to a more stable growth pattern in the long term.

The macroeconomic analysis assumes that a marketable emission permit system, with a no cost allocation of permits will be put into place, patterned after the EPA's Acid Rain Program.¹⁵ In order to meet their targets, power plants producers would be free to buy and sell allowances at a free market price for the permits, reflecting the marginal cost of abatement for any given emission.

¹⁴ Energy Information Administration, "Energy Price Impacts on the U.S. Economy," <http://www.eia/doe/gov/emeu/steo/pub/contents.html>. April 2001.

¹⁵ Environmental Protection Agency, "Acid Rain Program," <http://www.epa.gov/airmarkets/html>. August 2001.

With respect to impacts of emission limits on the reference case; capital, labor, and production processes would need to make the needed adjustments in order to accommodate higher energy and non-energy prices. The higher energy prices will affect all sectors of the economy, including households that would need to adjust spending patterns in the face of higher energy prices. Under the reference case, higher energy prices will cause production costs to rise over the short term, for both intermediate and final goods and services in the economy, but will level out under this scenario, by no later than 2020.

With respect to impacts of emission limits on the advanced technology case; the impact from rising energy prices is more moderate compared to the reference case. The advanced technology case incorporates more rapid improvements for electricity generation, fossil fuel supply technologies, and end-user demand compared to the reference case. Since the impacts on energy prices are less under this scenario, the impacts on the economy should also be less. The advanced technology scenario projects a lower demand for energy and there are less emissions because of the introduction of more advanced and more efficient technologies at a lower cost.¹⁶

¹⁶ Energy Information Administration, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants with Advanced Technology Scenarios," SR/OIAF/2001-05 (October 2001).

CHAPTER III

ENERGY INFORMATION ADMINISTRATION'S MODEL, ANALYSES, AND FORECASTS

Introduction

The National Energy Modeling System (NEMS) is a computer-based, energy and economic modeling system of United States energy markets used to project supply and demand markets over a mid-level period of time, usually in the range of 20-25 years. NEMS was created and implemented by the Energy Information Administration (EIA), a branch of the United States Department of Energy (DOE). NEMS projects the production, imports, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, resource availability and costs, world energy markets, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics.

NEMS standard equation solving techniques are Jacobi and Gauss-Seidel algorithms.

The NEMS integrating algorithm is an application of the Gauss-Seidel algorithm designed to solve a set of simultaneous nonlinear equations. The approach partitions the equations and variables into subsets. Each subset of equations is solved keeping the other variables constant at their trial values. The process is repeated for each subset, updating the trial values for each variable from the prior solution.

NEMS is also used by EIA to project the energy, economic, environmental, and security impacts on the United States of alternative energy policies and of various assumptions about energy markets.¹⁷ In addition, NEMS can estimate the impacts of transitions to new energy programs and policies. Forecast timeframes for NEMS are periodically extended to approximately 20 to 25 years into the future. This appears to be a sufficient enough period of time in which demographics, economic conditions, and technology are sufficiently understood in order to represent energy markets with a reasonable degree of certainty.

For the purpose of this study, projections are made for each year from 2000 through 2020, based on actual numbers (data) from 1999.

Across the United States energy resources and prices, consumption, demand for specific energy services, and other characteristics of energy markets can greatly vary. NEMS was designed as a regional model to address these variances and therefore reduce variability. The basic regional structure is based on the nine Census divisions; however, different modules of NEMS represent a variety of regional structures.¹⁸

The regional and divisional variance for each module reflects the availability of data and the regions used by other energy analysts in that area, as well as the regions determined to be most useful for policy analysis. A

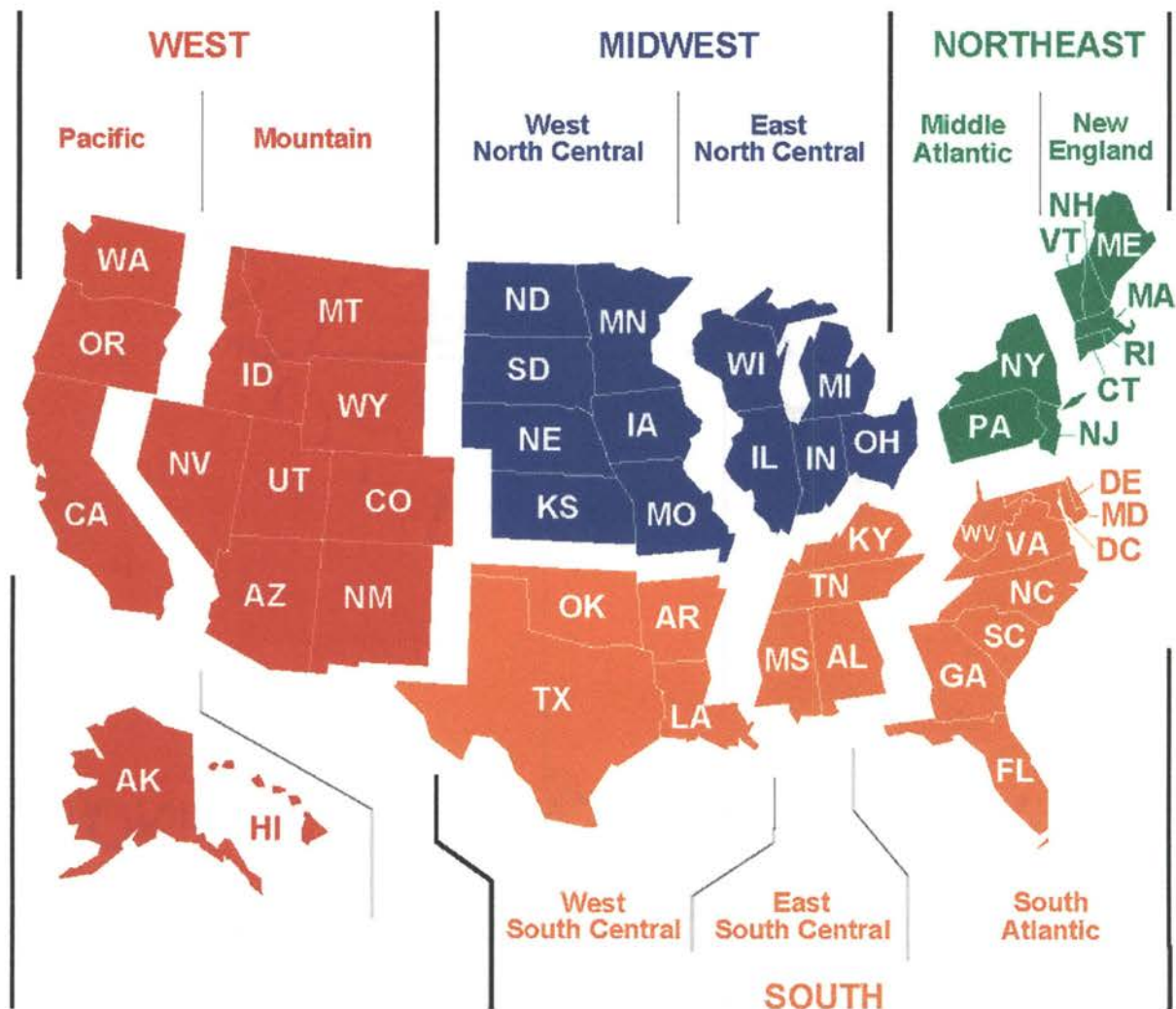
¹⁷ Energy Information Administration, "The National Energy Modeling System: An Overview 2000," DOE/EIA – 0581 (March 2000).

¹⁸ Energy Information Administration, "The National Energy Modeling System: An Overview 2000," DOE/EIA – 0581 (March 2000).

breakdown of the U.S. Census regions and divisions are highlighted in Figure 3.1.

FIGURE 3.1

U.S. CENSUS REGIONS AND DIVISIONS (2001)



Annual baseline forecasts are developed by NEMS and published in the Annual Energy Outlook. The EIA is required to remain policy neutral; therefore, the Annual Energy Outlook projections assume that all existing legislation, regulations, and policies remain unchanged. In addition, analyses are also prepared in response to requests for special studies by the United States Congress, the DOE office of policy, other offices within DOE, and other government agencies.

Since NEMS forecasts are based on key assumptions made about U.S. energy systems, these forecasts are not considered to be absolute predictions of the future. Some of the assumptions include, the estimated size of the economically recoverable resource base of fossil fuels, changes in world energy supply and demand, the rate at which new technologies are developed and implemented, and the extent of new government based policies and programs.

Model Analysis Capabilities

NEMS is used to analyze a wide variety of existing and proposed regulations and their projected effects from different vantage points. For example, NEMS can be used to analyze the effects of existing and proposed government laws and regulations concerning energy production and use. NEMS can also be used to project the potential impacts from new and advanced energy production, conversion, and consumption technologies; the impacts from increased use of renewable energy sources; the impacts and costs of reducing carbon dioxide emissions; the potential savings from increased efficiency of

NEMS analytical capabilities include the examination of reoccurring events or topics, one-time analytical reports and papers, and special requests for analyses.

Examples of reoccurring topics or events that have been addressed by NEMS include:

- Impacts of energy tax policies on the U.S. economy and energy system.
- Impacts on energy prices, energy consumption, and electricity generation of carbon mitigation policies such as carbon fees, limits on carbon emissions, or permit trading systems.
- Responses of the energy and economic systems to changes in world oil market conditions as a result of changing levels of foreign production and demand in the developing countries.
- Impacts of new technologies on consumption and production patterns and emissions.
- Impacts on the production and price of crude oil and natural gas resulting from improvements in exploration and production technologies.
- Impacts on the price of coal resulting from improvements in productivity.

Examples of one-time analyses include:

- *Electricity Prices in a Competitive Environment: Marginal Cost Pricing of Generation Services and Financial Status of Electric Utilities.*

Examples of special analyses include:

- *The Comprehensive Electricity Competition Act: A Comparison of Model Results*, requested by the Secretary of Energy to evaluate the impacts of the Administration's restructuring proposal using NEMS with the assumptions from the Policy Office Electricity Modeling System analysis.
- *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants with Advanced Technology Scenarios*, requested by Senators James M. Jeffords and Joseph I. Lieberman to analyze impacts and costs from implementing multiple emissions reductions.
- *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity*, requested by the Committee on Science of the U.S. House of Representatives to analyze the Kyoto Protocol, focusing on U.S. energy use and prices and the economy in the 2008 to 2012 time frame.
- *Energy Consumption Projections for Selected Industries of the Future*, requested by the Office of Industrial Technologies, Office of Energy Efficiency and Renewable Energy, DOE, to provide projections of output and delivered energy consumption for selected industries included in the Industries of the Future Program.
- *The Impacts on U.S. Energy Markets and the Economy of Reducing Oil Imports*, requested by the General Accounting Office to evaluate

the impacts of reducing oil imports on U.S. energy markets and the economy.

- *An Analysis of FERC's Final Environmental Impact Statement for Electricity Open Access and Recovery of Stranded Costs*, requested by Senator James Jeffords of Vermont to analyze the impacts of open access regulatory changes on the electricity industry.

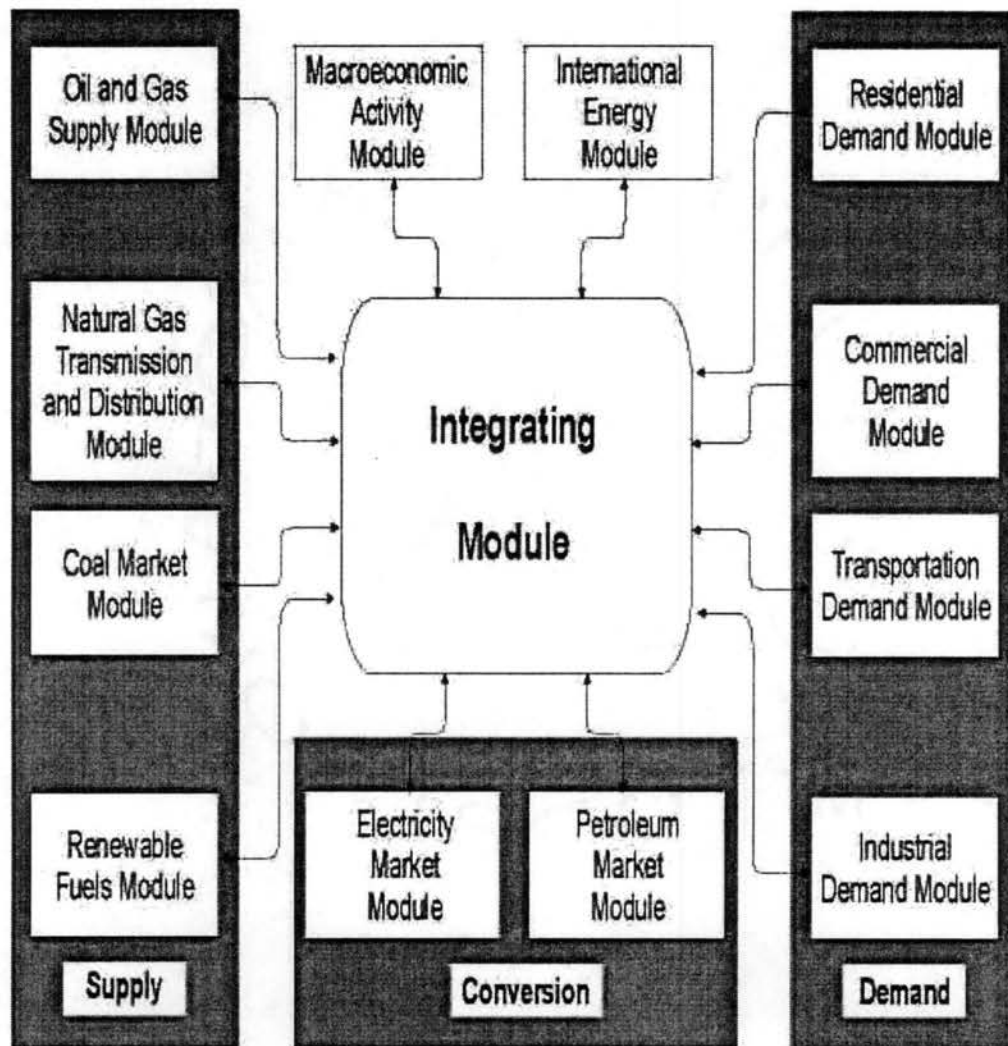
Model Design, Methodology, and Structure

NEMS is designed to represent the major interactions of supply and demand in America's energy markets. A diagram of the National Energy Modeling System is depicted in Figure 3.2¹⁹.

¹⁹ Energy Information Administration, "The Electricity Market Module of the National Energy Modeling System," DOE/EIA – M068 (February 2001).

FIGURE 3.2

National Energy Modeling System (NEMS)



The model computes analyses of energy-related activities and then provides forecasts over a 20 to 25 year period. NEMS represents the market behavior of the producers and consumers of energy at a high level of detail that is beneficial for analyzing the implications of technological improvements and policy initiatives.

NEMS is designed as a modular system. Delivered fuel prices, macroeconomic influences, and technology characteristics influence four-end use demand modules that represent fuel consumption in the residential, commercial, transportation, and industrial sectors. The primary fuel supply and conversion modules compute the levels of domestic production, imports, transportation costs, and fuel prices that will be needed to meet domestic and export demands for energy, subject to resource based parameters, industry infrastructure and technology, and worldwide market conditions. The modules interact to solve for the economic supply and demand balance for each fuel. In addition, because of the modular design, each sector can be represented with the methodology and level of detail, including regional and divisional detail that is appropriate for that sector. Because energy costs and availability and energy-consuming characteristics can vary considerably across the U.S., NEMS includes considerable regional detail. Details of production and consumption categories are represented to facilitate policy analysis and to ensure validity of the results. A summary of the detail provided in NEMS is highlighted in Table 3.1²⁰ below.

²⁰ Energy Information Administration, "The National Energy Modeling System: An Overview 2000," DOE/EIA – 0581 (March 2000).

TABLE 3.1

Energy Activity, Categories, and Regions

Energy Activity	Categories	Regions
Residential demand	Fourteen end-use services Three housing types Thirty-four end-use technologies	Nine Census divisions
Commercial demand	Ten end-use services Eleven building types Ten distributed generation technologies Sixty-four end-use technologies	Nine Census divisions
Industrial demand	Seven energy-intensive industries Eight non-energy-intensive industries Cogeneration	Four Census regions, shared to nine Census divisions
Transportation demand	Six car sizes Six light truck sizes Fifty-nine conventional fuel-saving technologies for light-duty vehicles Gasoline, diesel, and thirteen alternative-fuel vehicle technologies for light-duty vehicles Twenty vintages for light-duty vehicles Narrow and wide-body aircraft Six advanced aircraft technologies Medium and heavy freight trucks Ten advanced freight truck technologies	Nine Census divisions
Electricity	Eleven fossil technologies Seven renewable technologies Conventional and advanced nuclear Marginal and average cost pricing Generation capacity expansion	Fifteen electricity supply regions Nine Census divisions for demand
Renewables	Wind, geothermal, solar thermal, solar photovoltaic, municipal solid waste, biomass, conventional hydropower	Fifteen electricity supply regions
Oil supply	Conventional onshore and shallow offshore Conventional deep offshore Enhanced	Six lower 48 onshore regions Three lower 48 offshore regions Three Alaska regions
Natural gas supply	Conventional onshore and shallow offshore Conventional deep offshore Coalbed methane Gas shales Tight sands Canadian, Mexican, and liquefied natural gas	Six lower 48 onshore regions Three lower 48 offshore regions Three Alaska regions Five liquefied natural gas terminals
Natural gas transmission and distribution	Core vs. noncore Peak vs. offpeak Pipeline capacity expansion	Twelve lower 48 regions Ten pipeline border points
Refining	Five crude oil categories Seven product categories Thirty-three technologies Refinery capacity expansion	Three refinery regions aggregated from Petroleum Administration for Defense Districts
Coal supply	Three sulfur categories Four thermal categories Underground and surface mining types	Eleven supply regions Thirteen demand regions Sixteen export regions Twenty import regions

For example, NEMS can capture feedback between the domestic economy and energy systems on a regional level and then further breakdown to a divisional level. Changes in energy prices affect key macroeconomic variables such as gross domestic product, personal income, industrial output, housing starts, employment, and interest rates to name a few- all of which drive energy consumption and capacity expansion decisions.

NEMS can also look at domestic versus world energy market interactions and distill these findings down to the regional divisional level. The international energy module looks at the interactions between the domestic and world oil markets and can calculate an average world crude oil price and the supply of specific crude oils and petroleum products. This results in domestic and world oil market projections being internally consistent. Imports and exports of natural gas, electricity, and coal are represented in the individual fuel supply modules. These modules are less susceptible to volatile world market conditions. Many assumptions about planning horizons, formation of expectations concerning the future, and the role of those expectations in economic decision-making are applied within individual NEMS modules.

Technology representation is a key feature designed within NEMS. NEMS evaluates technology and technology improvement over time. Residential, commercial, transportation, refining, and electricity generation are sectors that include explicit treatment of individual technologies and their various characteristics, such as initial cost, operating cost, efficiency, date of availability, plus other characteristics specific to that particular sector. Treatment of

technologies are more limited in some sectors such as industrial, oil and gas supply, and coal supply, due to limitations on the availability of data on individual technologies.

Each module of NEMS includes multiple assumptions and data that are used to characterize the future production, conversion, or consumption of energy in the United States. Each module within NEMS is discussed below.

Integrating Module

The integrating module is the heart and soul of NEMS. This module controls the NEMS solution process through an iterative convergence algorithm procedure that determines general market equilibrium across all the NEMS modules. The integration module has the following functions:

- Manages the NEMS global data structure
- Executes all modules that have been selected via an iterative process
- Checks for convergence, and reports variables that remain out of convergence
- Implements price relaxation between iterations to increase convergence
- Updates expected values of the key NEMS variables.

The integrating module executes the demand, conversion, and supply modules using an iterative convergence algorithm until it achieves an economic equilibrium of supply and demand in all the consuming and producing sectors. Each module is taken in sequence and solved, assuming that all other variables in the energy market are fixed. Each module is called iteratively until the end-use

prices and quantities remain constant within a given tolerance - a condition defined as convergence. Equilibration is achieved on an annual basis throughout the projected period, currently 2020, for each of the nine Census divisions.

Macroeconomic Activity Module

The macroeconomic activity module (MAM) links NEMS to the rest of the economy by providing projections of economic driver variables for use by the supply, demand, and conversion modules of NEMS. Macroeconomic variables such as gross domestic product (GDP), disposable income, industrial gross output, employment, inflation, and interest rates drive energy demands and are important determinants of energy quantities and prices. Changes in energy supplies and prices can in turn affect macroeconomic variables. To capture these effects, NEMS allows for feedback to and from the macroeconomy.²¹

The macroeconomic activity module provides forecasts of economic variables to the energy modules within NEMS and forecasts the impacts on the aggregate economy of changes in energy market conditions. The macroeconomic module is composed of five sub-modules: the National Sub-module, the Inter-industry Sub-module, the Employment Sub-module, the Regional Sub-module, and the Commercial Floor space Sub-module, which are run in sequence. Macroeconomic concepts, industry gross output, and employment levels are passed back to the other NEMS modules, and the system iterates until convergence is achieved. System outputs include measures of

²¹ Energy Information Administration, "Model Documentation Report: Macroeconomic Activity Module (MAM) of the National Energy Modeling System," DOE/EIA – M065 (January 2002).

macroeconomic performance and manufacturing and non-manufacturing sector production activities. These measures can be provided nationally or at the geographic level of the nine Census divisions.

International Energy Module

The international energy module (IEM) looks at world oil market issues and forecasts mid-to long-term world oil prices. The IEM attempts to address international issues and their interaction with U.S. markets. The international energy module is composed of four sub-modules: the World Oil Market Sub-module, the Crude Oil Supply Sub-module, the Petroleum Products Supply Sub-module, and the Oxygenates Supply Sub-module.

The components of the international energy module accomplish the following:

- Calculate the average world oil price and provide supply curves for five grades of crude oil for import to the United States
- Calculate the change in the world oil price in response to shifts in the U.S. import demands
- Provide crude oil and petroleum product supply curves with a representation of foreign supply levels and associated costs for U.S. petroleum imports. Calculate shifts in import supply curves as world oil market conditions vary
- Provide supply curves for U.S. imports of oxygenates (Methyl tertiary butyl ether (MTBE) and methanol).²²

²² Energy Information Administration, "Model Documentation Report: International Energy Module (IEM) of the National Energy Modeling System," DOE/EIA – M071 (February 1999).

All the sub-modules of IEM, plus all other modules of NEMS use the world oil price that is generated by the world oil market sub-module. The import supply curves for crude oils, refined products, and oxygenates are used by the petroleum market module.

Residential Demand Module

The Residential Demand Module (RDM) uses inputs from the NEMS system to generate outputs needed in the NEMS integration process. The inputs required by the RDM from the NEMS include energy prices and macroeconomic indicators.²³

The residential demand module forecasts energy consumption by Census division for seven marketed energy sources including solar and geothermal energy. RDM is a structural model and its forecasts are built from projections of the residential housing stock and from energy consuming equipment. NEMS provides forecasts of residential energy prices, population, and housing starts, which are used by RDM to develop forecasts of energy consumption by fuel and Census division.

RDM incorporates the effects of four broadly defined determinants of energy consumption: market effects, economic and demographic effects, structural effects, and technology turnover and advancement effects.

²³ Energy Information Administration, "Model Documentation Report: Residential Sector Demand Module (RDM) of the National Energy Modeling System," DOE/EIA – M067 (December 2001).

RDM is also used as an analysis tool to address current and proposed legislation and technology developments that affect the residential sector. Examples of policy analyses include assessing potential impacts of the following:

- New end-use technologies
- Changes in fuel prices due to tax policies.
- Financial incentives for energy efficiency investments

Commercial Demand Module

The Commercial Demand Module (CDM) is a simulation tool based upon economic and engineering relationships that models commercial sector energy demands at the nine Census division level of detail for eleven distinct categories of commercial buildings. Commercial equipment selections are performed for the major fuels consisting of electricity, natural gas, and distillate fuel, for the major services of space heating and cooling, water heating ventilation, cooking, lighting, and refrigeration. The market segment level of detail is modeled using a constrained life cycle cost minimization algorithm that looks at commercial sector consumer patterns and time preference premiums.²⁴

Forecasts from the CDM include energy consumption by Census division for eight marketed energy sources including solar and geothermal energy. The commercial sector highlights business establishments that are not engaged in industrial or transportation activities. And similar to the residential demand model, the CDM incorporates the effects of four broadly defined determinants of

²⁴ Energy Information Administration, "Model Documentation Report: Commercial Sector Demand Module (CDM) of the National Energy Modeling System," DOE/EIA – M066 (December 2001).

energy consumption: market effects, economic and demographic effects, structural effects, and technology turnover and advancement effects.

Industrial Demand Module

The Industrial Demand Model (IDM) receives fuel prices, employment data, and the value of industrial output from the NEMS system. Based on the values of these variables, the industrial demand model passes back to the NEMS system estimates of consumption by fuel types. The industrial demand model does not project seasonal or daily variations in fuel demand or fuel prices.²⁵

The (IDM) forecasts energy consumption for fuels and feedstocks for nine manufacturing industries and six non-manufacturing industries, subject to delivered prices of energy and macroeconomic variables representing the value of output for each industry. The influence of energy prices on industrial energy consumption is modeled in terms of the efficiency of use of existing capital, the efficiency of new capital acquisitions, and the mix of fuels utilized, given existing capital stocks. Energy conservation from technological change is represented over time by trend-based “technology possibility curves.” These curves represent the aggregate efficiency of all new technologies that are likely to penetrate the future markets as well as the aggregate improvement in efficiency of 1994 technology.

²⁵ Energy Information Administration, “Model Documentation Report: Industrial Sector Demand Module (IDM) of the National Energy Modeling System,” DOE/EIA – M064 (December 2001).

IDM incorporates three major industry categories: energy-intensive manufacturing industries, non-energy intensive manufacturing industries, and non-manufacturing industries.

Transportation Demand Module

The Transportation demand Module (TDM) generates mid-term forecasts of transportation sector energy consumption, including the use of renewable and alternative fuels, subject to delivered prices of energy fuels and macroeconomic variables. The TDM facilitates policy analysis of energy markets, environmental issues, regulatory development, and technological development as they relate to transportation sector energy consumption.

Detail wise, the TDM incorporates an integrated modular design which is based on economic, engineering, and demographic relationships that model transportation sector energy consumption at the Census division level. The TDM is comprised of the following components: light duty vehicles, light duty fleet vehicles, commercial light trucks, freight transport (including truck, rail, and marine), aircraft, and miscellaneous transport (military, mass transit, and recreational boats). The model produces sales estimates of two conventional and fourteen alternative fuel light duty vehicles, plus consumption estimates of twelve main fuels.²⁶

²⁶ Energy Information Administration, "Model Documentation Report: Transportation Demand Module (TDM) of the National Energy Modeling System," DOE/EIA – M070 (February 2001).

The NEMS projections of future fuel prices influence the fuel efficiency, vehicle miles traveled, and the alternative fuel vehicle market penetration for the current fleet of vehicles.

Electricity Market Module

The Electricity Market Module (EMM) provides a major link within the NEMS framework. NEMS supplies electricity demand, fuel prices, macroeconomic parameters, and expectations from the system module to the EMM. The EMM then estimates the actions taken by electric utilities and non-utilities to meet demand in the most economical manner. The EMM then outputs electricity prices to the demand modules, fuel consumption to the fuel supply modules, emissions to the system module, and capital requirements to the macroeconomic module. The entire model is then iterated until a solution is reached for that particular year.

The EMM represents the capacity planning, generation, transmission, and pricing of electricity, subject to delivered prices for coal, petroleum products, and natural gas. Also included are the cost of centralized generation facilities, macroeconomic variables for costs of capital and domestic investment, and electricity load shapes and demand. The sub-models consist of capacity planning, fuel dispatching, finance and pricing, and load and demand-side management. Non-utility supply and electricity trade are also represented in the fuel dispatching and capacity planning sub-modules. Non-utility generation from co-generators and other facilities whose primary business is not electricity

generation is represented in the demand and fuel supply modules. All other non-utility generation is also represented in EMM. The generation of electricity is accounted for in thirteen supply regions, and fuel consumption is allocated to the nine census divisions.²⁷

Renewable Fuels Module

The Renewable Fuels Module (RFM) consists of five analytical sub-modules that represent major renewable energy resources: biomass, landfill gas, solar, wind, and geothermal energy.

The purpose of the RFM is to define the technology, cost, performance, and resource size characteristics of renewable energy technologies. These interactions are provided to the EMM for grid-connected central station electricity capacity planning and dispatch decisions. The characteristics include available generating capacity, location, unit size, capital cost, fixed operating cost, heat rate, capacity factor, variable operating cost, fuel price, and construction lead time.²⁸ The penetration of grid connected generation technologies, except for municipal solid waste, is determined by the EMM. Hydropower is included in the EMM directly.

Each RFM sub-module is solved independently of the rest. All available renewable generating capacity is dispatched first by the EMM because variable operation and maintenance costs for renewable technologies are lower versus

²⁷ Energy Information Administration, "Model Documentation Report: Electricity Market Module (EMM) of the National Energy Modeling System," DOE/EIA – M068 (February 2001).

²⁸ Energy Information Administration, "Model Documentation Report: Renewable Fuels Module (RFM) of the National Energy Modeling System," DOE/EIA – M069 (February 2002).

other major generating technologies and because there is almost no air pollution with renewable technologies. Costs for renewable energy technologies increase when supply expands rapidly - usually greater than twenty five percent per year on a national scale.

Oil and Gas Supply Module

The Oil and Gas Supply Module (OGSM) projects production estimates of United States crude oil and natural gas based on supply functions generated endogenously within NEMS. The OGSM encompasses domestic crude oil and natural gas supply via conventional and non-conventional recovery techniques. Non-conventional recovery includes enhanced oil recovery, and unconventional gas recovery from tight gas formations, shale, and coal beds. OGSM projects United States domestic oil and gas supply for six Lower forty eight onshore regions, three offshore regions, and Alaska. OGSM methodology relies on forecasted profitability to determine exploratory and developmental drilling levels for each region and fuel type. These projected drilling levels translate into reserve additions, as well as a modification of the production capacity for each region.²⁹ The main assumption of OGSM is that domestic oil and gas exploration and development are undertaken if the discounted present value of the recovered resources at least covers the present value of taxes and the cost of capital, exploration, development, and production.

²⁹ Energy Information Administration, "Model Documentation Report: Oil and Gas Supply Module (OGSM) of the National Energy Modeling System," DOE/EIA – M063 (January 2001).

In contrast, international gas trade is determined in part by scenario dependent, non-economic factors. Crude oil is transported to refineries, which are simulated in the petroleum market module, for conversion and mixing into refined petroleum products.

The OGSM utilizes both exogenous input data and data from other modules within the NEMS system. The individual sub-modules of the oil and gas supply module are solved independently, with feedbacks achieved via the NEMS iterative process.

Natural Gas Transmission and Distribution Module

The Natural Gas Transmission and Distribution Module (NGTDM) represents the natural gas market and projects regional market clearing prices for natural gas supplies and for end use consumption, using information derived from other modules within the NEMS.

The NGTDM represents the transmission, distribution, and pricing of natural gas. This module also includes representations of the end use demand for natural gas, the production of domestic natural gas, and the availability of natural gas traded on the international market, based on data received from other modules within NEMS. The NGTDM links natural gas suppliers (including importers) and consumers in the Lower forty eight States and across the Canadian and Mexican borders through a natural gas transmission and distribution network, while at the same time determining the flow of natural gas and the regional market clearing prices between suppliers and consumers. Even

though the focus of the NGTDM is on domestic natural gas markets, there is a simplified representation of the Canadian natural gas market that has been incorporated within this module as well. Twice a year the NGTDM determines the production, flows, and prices of natural gas in an aggregate (United States and Canadian pipeline network), connecting domestic and foreign supply regions with twelve United States and two Canadian demand regions. Because the NEMS operates on an annual basis, the NGTDM results are transferred to other NEMS modules representing annual totals or quality-weighted averages.³⁰

A sophisticated transmission and distribution network is used to simulate the interregional flow and pricing of gas in the United States and Canada for both the peak (December through March) and the off-peak (April through November) periods.

Petroleum Market Module

The Petroleum Market Module (PMM) models petroleum refining and marketing. The PMM is a regional, linear programming representation of the United States petroleum market. This module assumes that the petroleum refining and marketing industry is competitive.

The purpose of the petroleum market module is to project petroleum product prices, refining activities, and movements of petroleum into the United States and within domestic regions. The module models petroleum refining

³⁰ Energy Information Administration, "Model Documentation Report: Natural Gas Transmission and Distribution Module (NGTDM) of the National Energy Modeling System," DOE/EIA – M062 (February 2001).

activities, the marketing of petroleum products to consumption regions, the production of natural gas liquids in gas processing plants, and domestic methanol and ethanol productions. In addition, the module projects petroleum product prices and sources of supply for meeting petroleum product demand. Sources of supply include crude oil, both domestic and imported, plus other inputs including alcohols and ethers, natural gas plant liquids production, petroleum product imports, and refinery processing gain. Also, the petroleum market module estimates domestic refinery capacity expansion and fuel consumption. Product prices are estimated at the Census division level and a lot of the refining activity information is located at the Petroleum Administration for Defense District (PADD) level.³¹

The petroleum market module can be used to analyze a wide variety of petroleum based issues and policies, which in turn helps to promote a better understanding of the petroleum refining and marketing industry and the effects of various policies and regulations.

Coal Market Module

The Coal Market Module (CMM) represents the mining, transportation, and pricing of coal, subject to end user demand. Coal supplies are scored based on heat and sulfur content. The CMM consists of two sub-modules: the Coal Production Sub-module and the Coal Distribution Sub-module. Basically, the

³¹ Energy Information Administration, "Model Documentation Report: Petroleum Market Module (PMM) of the National Energy Modeling System," DOE/EIA – M059 (February 2001).

CMM provides annual forecasts of prices, production, and consumption of coal for the NEMS.³²

In addition, CMM determines the minimum cost pattern of coal supply to meet exogenously defined United States coal export demands as a part of the world coal market. The coal supply is estimated on a cost-minimizing basis, governed by existing contracts. Twelve separate coal types are differentiated with respect to thermal grade, sulfur content, and underground or surface mining. Forecasted coal production and distribution is based on thirteen demand regions and eleven supply regions.

Solutions for the components of CMM are found simultaneously. Coal supply curves are produced by the coal production sub-module and inputted to the coal distribution sub-module. The coal distribution sub-module estimates delivered coal prices based on the coal supply curves, coal demand, and distribution costs. The module is iterated to convergence with respect to equilibrium prices in all demand sectors.

National Impact of Multiple Emissions Regulations

At the time of this writing, several different scenarios exist that address various environmental issues and multiple emission regulations. An example of one such environmental issue at the National level concerns regional air pollution effects that might result from new opportunities for inter-regional power transmission from more competitive electricity markets (i.e. merchant power

³² Energy Information Administration, "Model Documentation Report: Coal Market Module (CMM) of the National Energy Modeling System," DOE/EIA – M060 (January 2000).

plants). Regional focus is of concern because of the differences in efficiency and plant utilization rates of existing generating capacity, including differences in emission rates, production costs, and electricity price. Increased competition in generation could cause changes in the regional profiles of generation and emissions.³³

Additionally, the potential for new emission standards with variable timetables adds a certain degree of uncertainty for electric power plant generators including tasks such as investment planning decisions. As a result, power plant owners are somewhat in limbo when it comes to making investments that might prove costly and unnecessary within a few years.

This analysis looks at proposed legislation that would require simultaneous reductions of multiple emissions. Several bills have been introduced in Congress for this very purpose – to reduce power plant emissions of NO_x, SO₂, Hg, and CO₂ simultaneously over the next decade or so. There appears to be a general agreement that a more streamlined emission reduction policy is needed, even though differences exist in regard to what the appropriate emission limits should be and how the program should be implemented.

The analysis looks at the possible impacts on energy markets that could occur from actions taken by power suppliers to meet the emission limits specified in the cases. All cases are required to have the same implementation date and the same levels for the four emissions. The differences among the cases involve additional assumptions and programs that foster faster technology development,

³³ Karen Palmer and Dallas Burtraw, Resources for the Future, "Electricity Restructuring and Regional Air Pollution," Discussion Paper 96-17-Rev 2, July 1996.

including the adoption and penetration of more energy efficient and renewable technologies. Some of the key findings from a National point of view include:

- Reducing NO_x and SO₂ emissions in the electric power plant generation sector to seventy-five percent below their 1997 levels should lead to a large increase in the amount of pollution control equipment being installed with little change in fuel use for electric power producers. Significant costs are projected for the electric power plant generators, however electricity prices are projected to be only slightly higher than the reference case numbers.
- Reducing Hg emissions in the electric power plant generation sector to ninety percent below their 1997 level should lead to a large increase in the amount of pollution control equipment being installed for generators of electricity. Cost and price impacts to reduce Hg emissions to the above mentioned limits are projected to be greater than those of reducing NO_x and SO₂ emissions. Mercury control technologies lack sufficient full-scale test data on existing generating units; therefore, there remains considerable uncertainty with regard to the performance and cost of Hg control technologies. Various technology studies concerning Hg reduction are underway at this time.
- Projected impacts from reducing CO₂ emissions in the electric power plant generation sector that is seven percent below 1990 levels should dominate the impacts of limits on other emissions. The major compliance strategy in cases that include CO₂ emissions reductions

include a large shift in power plant fuel consumption from coal to natural gas and, to a lesser extent, renewables and nuclear power (increased plant life extension for existing nuclear power plants). In addition, end-users are projected to reduce their consumption of electricity in response to increased electricity prices.

From a National prospective, it is necessary to realize that there are multiple policy instruments available for reducing emissions such as; technology standards, percentage reduction standards, emission allowance actions with cap and trade programs, emission taxes, no-cost emission allowance allocation with cap and trade programs, and annual generation performance standard emission allowance allocations with cap and trade programs. Every one of these approaches has different implications for the resource cost, price, and economic impacts of the emission reduction program. Overall, an efficient cap and trade program should lead to the lowest resource cost of compliance.³⁴

Impact of Multiple Emissions Regulations in Oklahoma

The impact of these multiple regulations on the Oklahoma economy could be both positive and negative. As stated above, the potential for new emission standards with multiple timetables adds a certain degree of uncertainty for electric generators in general and this will have a very real impact on Oklahoma power producers and the Oklahoma economy.

³⁴ Energy Information Administration, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants with Advanced Technology Scenarios," SR/OIAF/2001-05 (October 2001).

One way to reduce impacts could be through cap and trade programs. The oldest and most successful cap and trade program is the Acid Rain Program. Referring to the acid rain program and using SO₂ as an example, under phase I, a certain number of allowances have been allocated to every power plant. One allowance allows a plant to emit one ton of pollutant, in this case SO₂. In order for that plant to continue to operate, it must possess allowances equal to the amount of pollution emitted. The effects are increased as different phases are implemented. Phase II of the acid rain program for SO₂ was implemented in 2000 which reduced the number of SO₂ allowances that are available to power plants across the nation (under phase II of the acid rain program SO₂ allowances have been reduced to 8.95 million total credits per year) therefore, fuel prices will be affected which should cause electric generating costs to rise.

Before the acid rain program was initiated, power plants in general could produce electricity with the required amount of equipment needed to meet pollution abatement requirements under their individual command and control permits. Therefore, theoretically a plant could continue to operate "as normal" and produce as much electricity as it could generate under the company's particular operating permit. As new regulations became law, some of the older plants weren't able to meet the more stringent requirements that came along with the new regulations (the cost of retrofitting the plant with new pollution control equipment would exceed the profit margin of producing electricity), therefore, many of these older plants sought and received "grandfather status" which

allowed them to continue to generate electricity for a certain amount of time (which many utilities interpreted as the life of the plant) without meeting the requirements of the new regulations. Costs are sure to increase as these older plants go off line because they can't comply with emission standards. Power producers will have the same or higher demand, but will be forced to build new plants or buy electricity from the grid at a potentially higher price.

Most coal, fuel oil, and gas generating plants will need some amount of allowances each year for plant operation. The master generating plan will need to be reviewed and updated as these multiple emission regulations become law. Some of the key factors that will drive future plant expansion in Oklahoma include:

- Reducing NO_x and SO₂ emissions in the electric power plant generation sector to seventy-five percent below their 1997 levels. Oklahoma power plants, especially coal plants, should see the need for a large increase in the amount of pollution control equipment needed. For these power plants, especially under retrofit, significant increases in costs are projected in order to continue to generate the same amount of power.
- Reducing Hg emissions in the electric power plant generation sector to ninety percent below their 1997 level should lead to additional amounts of pollution control equipment that will need to be installed for power plant generators. Cost and price impacts to reduce Hg emissions to the above mentioned limits are projected to be greater than those of

reducing NO_x and SO₂ emissions. In addition, mercury control technologies lack sufficient full-scale test data on existing generating units; therefore, there remains considerable uncertainty with regard to the performance and cost of Hg control technologies.

- Projected impacts from reducing CO₂ emissions for the Oklahoma electric power plant generation sector that is seven percent below 1990 levels should have a hefty impact especially for Oklahoma coal plants. Oklahoma's major compliance strategy in cases that include CO₂ emissions reductions will probably include a large shift in power plant fuel consumption from coal to natural gas and, to a lesser extent, renewables. In addition, end-users in Oklahoma are projected to reduce their consumption of electricity in response to increased electricity prices.

From a State prospective, it is necessary to realize that there are multiple policy instruments available for reducing emissions such as; technology standards, percentage reduction standards, emission allowance actions with cap and trade, emission taxes, no-cost emission allowance allocation with cap and trade, and annual generation performance standard emission allowance allocations with cap and trade. Every one of these approaches has different implications for the resource cost, price, and economic impacts of the emission reduction program. Overall, an efficient cap and trade program should help Oklahoma with a cost of compliance strategy.

In summary, as demand for electricity goes up and emission allowances decrease in the market place, this will most likely affect fuel prices; probably causing fuel prices to increase which in turn will drive up the price for electricity. Since the electric commodity market is much different than other commodity markets due to the lack of physical storage and various transmission constraints that exist on the system, pricing electricity could become much more volatile.³⁵ Due to the non-storability of electricity and the volatility of the market, traditional pricing strategies might not be able to be used to price electricity forward looking.

The Emission Trading Industry

NEMS assumptions do expect a fully functional trading market. NEMS has not been used to simulate scenarios where emissions trading is a variable, however, NEMS does incorporate basic assumptions of emissions trading in all of their scenarios.

Creation of the emission credit trading industry started with Title IV of the Clean Air Act Amendments of 1990 and the birth of the Acid Rain Program. This program is an innovative program used designed to harness the power of the market place to combat acidic deposition using tradable allowances and free market incentives.³⁶ Through this market-based approach model, emissions trading schemes have been developed to help companies deal with pollution

³⁵ Research Activities, "Energy, resources, and environment," <http://www.hut.fi/UNITs/SAL/Research/act94re-3.html>.

³⁶ James L. Johnston, The Cato Review of Business and Government, "A Market without Rights: Sulfur Dioxide Emissions Trading," <file:///D:/reg14n4-johnston.htm>. Cato Institute.

emission problems. The availability of allowances are critical to both the efficiency of the emissions program and the addition of new electric generating capacity. The fact that emission credits have value and can be treated as a commodity to be sold or traded gives businesses an incentive to reduce their emissions. Emissions trading are sometimes referred to as buying the “right to pollute.”³⁷

The primary focus of the emissions credit trading industry is to develop a tradable permits system that will help businesses reduce overall costs and at the same time give these businesses a continuing incentive to cut emissions. The emissions trading market has started off slowly due to the fact that there is uncertainty in the market place on just how many credits will be available and if “banked” credits are going to be allowed for use in the future. Emission trading programs include issues such as: monitoring and verification, certification, reporting, compliance and enforcement, and accountability.³⁸

To date, emission markets in the United States exist for sulfur dioxide, nitrogen oxides, volatile organic carbons, carbon monoxide, carbon dioxide, and particulate matter to name a few. Emission markets should expand as multiple emission regulations come into focus and are embraced as law. Allowances are traded based on an estimated fair market value. Brokerage firms such as Cantor Fitzgerald Brokerage Services use a Market Price Index™ (MPI) System to trade

³⁷ Commodities-Now-CN Online-Article, “Will Emissions Trading Ever Take Off?”, <http://www.commodities-now.com/cnonline/dec2000/article4/a4-p1.html>.

³⁸ Emission Trading 101, “At the Negotiating Table”, <http://www.weathervane.rff.org/negotiable.html>.

credits. MPI is the price at which a buyer or seller would expect to transact environmental credits at any given time.³⁹ The MPI takes into account an average of the best bid, the best offer, and the most up-to-date transactions. Prices listed on the MPI exclude transaction fees imposed by regulatory agencies and /or market intermediaries. Emissions that apply to each State are listed along with current prices.

The Acid Rain Program's cap and trade system is the benchmark for the emission trading industry and serves as the blue print for future emission cap and trade programs. In addition, EPA has developed a SO₂ Allowance Tracking System that accounts for each unit that has a generating capacity of 25MW or greater. This program tracks the amount of credits allocated and used by each unit.⁴⁰ In the future, additional tracking programs will be developed that will enhance industry's effectiveness in dealing with emissions credit trading programs and energy efficiency.

³⁹ Cantor Fitzgerald Environmental Brokerage Service, "Market Price Index", <http://www.emissionstrading.com/marketp.htm>

⁴⁰ United States Environmental Protection Agency, "SO₂ Allowance Tracking System: Account/Representative Report", <http://www.epa.gov/airmarkets/tracking/ats/accounts.html>.

Model Forecasts

NEMS assumes that the U.S. economy will grow at an average annual rate of approximately 3.0 percent from 1999 through 2020. World oil prices and domestic natural gas prices are projected to decline over the next few years from their current high levels and then gradually increase in response to rising demand. Projections also assume a transition to full competitive pricing of electricity for States with specific deregulation plans and continued cost-of-service electricity pricing for States that don't have a specific deregulation plan. Electricity demand is projected to increase at an average annual rate of 1.8 percent between 1999 through 2020. Electricity generation fueled by natural gas and coal is projected to increase through 2020 to meet growing demand for electricity and to offset the projected loss of power plants due to retirement. In addition, total energy consumption is projected to increase at an annual rate of 1.3 percent per year through 2020. It is also assumed that cap and trade programs will be in effect and that there will be a robust amount of allowance trading taking place.

Estimated impacts on the U.S. economy of adopting the proposed regulations, using NEMS, are shown in table 3.2⁴¹. Detailed NEMS projection data for the reference and advanced technology cases are shown in appendix A.1.

⁴¹ Energy Information Administration, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants with Advanced Technology Scenarios," <http://www.eia.doe.gov.html> (October 2001).

TABLE 3.2

Electricity Projections For The Reference and Advanced Technology Cases

Electricity Projections in the Reference and Advanced Technology Cases, 2010 and 2020					
Projections	1999	Reference		Advanced	
		Without Emissions Limits	With Emissions Limits	Without Emissions Limits	With Emissions Limits
2010					
Average Delivered Electricity Prices (1999 Cents per Kilowatthour).....	6.7	6.1	8.0	5.9	7.4
Generation, Excluding Cogenerators (Billion Kilowatthours).....	3,369	4,204	3,914	4,125	3,885
Coal	1,830	2,238	1,276	2,240	1,324
Natural Gas	370	826	1,395	719	1,292
Renewables, Excluding Hydropower	46	95	189	101	213
Hydropower	310	301	303	301	302
2020					
Average Delivered Electricity Prices (1999 Cents per Kilowatthour).....	6.7	6.1	8.1	5.5	6.7
Generation, Excluding Cogenerators (Billion Kilowatthours)	3,369	4,821	4,311	4,674	4,309
Coal	1,830	2,302	1,041	2,246	1,146
Natural Gas	370	1,488	2,072	1,331	1,911
Renewables, Excluding Hydropower	46	99	217	109	223
Hydropower	301	300	302	300	301
Cumulative Additions of Emissions Control Equipment, 1999-2020 (Gigawatts)					
SO ₂ Scrubbers	-	17.5	37.0	9.8	40.5
Selective Catalytic Reduction (SCRs)	-	91.1	101.9	91.0	98.2
Selective Noncatalytic Reduction (SNCRs)	-	46.0	37.1	27.2	39.1
Hg Fabric Filters	-	0.0	88.3	0.0	95.7
Hg Spray Coolers	-	0.0	49.2	0.0	63.5

Built into each scenario are the costs to the electricity producing sector of meeting the proposed emission constraints. These costs include the purchase and installation of emissions control equipment, switching to alternative fuels, or the purchase of emissions permits. In general, electricity prices will increase by approximately 32% to 50 % by 2015, depending on the technology scenario adopted. Increased electricity generation fueled mostly by natural gas and coal is anticipated to meet a growing demand for electricity and to offset the projected

retirement of existing nuclear and fossil units. As a result of higher projected natural gas demand, natural gas prices in 2020 are anticipated to increase from 11 to 33 percent in all cases when the emission limits have been fully imposed. Also, the coal share is projected to decline from approximately 54 percent to 47 percent, because electricity industry restructuring favors the less capital-intensive and more efficient natural gas generation technologies.

For the most part, macroeconomic impacts should be nominal. The macroeconomic analysis assumes a marketable emission permit system is in place, with a no-cost allocation of tradable permits. Therefore, power suppliers would be free to buy and sell allowances at a market-determined price for the permits, which would represent the marginal cost of abatement for any given emission.

CHAPTER IV

IMPACTS OF MULTIPLE EMISSIONS REGULATIONS IN OKLAHOMA:

OKLAHOMA BRIDGE MODEL

Introduction

The regional focus is important because of significant variation in the vintage, efficiency and plant utilization rates of existing generating capacity, as well as differences in emission rates, cost of generation and electricity price. Increased competition in generation attributable to new regulations could produce changes in the regional profile of generation and emissions. In general, low cost regions are expected to export power generated by gas or coal fired facilities to higher cost regions.⁴²

Oklahoma is a member of the Southwest Power Pool (SPP) along with Kansas, and parts of Arkansas, Louisiana, Missouri, New Mexico, and Texas. A very small portion of Mississippi is also included in the SPP. However, Mississippi has no makeup to the SPP grid; Mississippi only transmits power from the SPP via two municipalities: the City of Clarksdale, Mississippi, and the Public Service Commission of Yazoo City, Mississippi.⁴³

The following is a percentage breakout of each states participating share in the Southwest Power Pool, based on the 2001 capacity level: Arkansas-

⁴² Karen Palmer, and Dallas Burtraw, "Electricity Restructuring and Regional Air Pollution," Resources for the Future, Discussion Paper 96-17-REV2, 1996.

⁴³ Southwest Power Pool, "Southwest Power Pool Members," <http://www.spp.org/About_Members.htm.>

4.30%, Kansas-22.67% (entire state included), Louisiana-8.56%, Missouri-14.04%, New Mexico-1.66%, Oklahoma-29.86% (entire state included), and Texas-18.91%. A breakdown of the states in the Southwest Power Pool is highlighted in the map in Figure 4.1.

From a regional prospective, projected changes in electricity generation within the Southwest Power Pool include the following:

- Electricity sales are anticipated to grow between 1.6 and 2.0 percent per year through at least 2015.
- Between 2005 and 2020, natural gas-fired generation will increase significantly. By 2015, approximately 21 gigawatts of new gas-fired combined –cycle units are anticipated to be built to meet varying levels of electricity demand.
- Electricity from renewable sources is anticipated to increase over 3 times the 1999 levels. The growth comes primarily from biomass and wind generation, and therefore reduces the need for increased coal and natural gas generation.⁴⁴

These projections from Southwest Power Pool members assume a marginal, if any at all, increase in emissions based regulations.

Expected Effects

The direct, or initial, impacts from multiple emission regulations on the Oklahoma economy will be both positive and negative. Table 4.1 indicates the

⁴⁴ Energy Information Administration, "Southwest Power Pool Information," http://www.eia.doe.gov/cneaf/electricity/chg_str_fuel/html/spp.html.

key direct impacts expected for Oklahoma and the probable direction of each impact. Electricity generated from gas fired plants and pollution control equipment production could have a significant positive impact on Oklahoma's economy. While electricity generating capacity could have a small positive impact on the Oklahoma economy.

In addition, Figure 4.2 graphically represents possible effects of multiple emissions regulations from a national and state overview.

FIGURE 4.1

Southwest Power Pool (SPP)

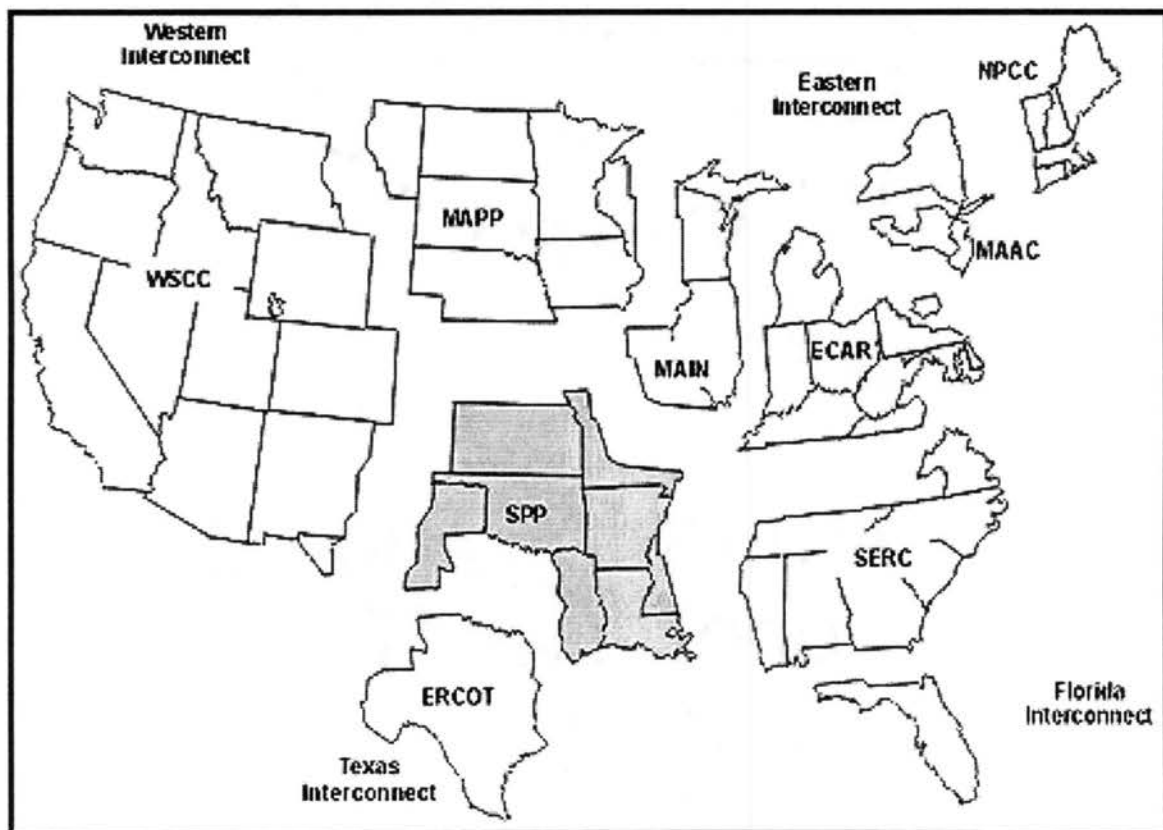


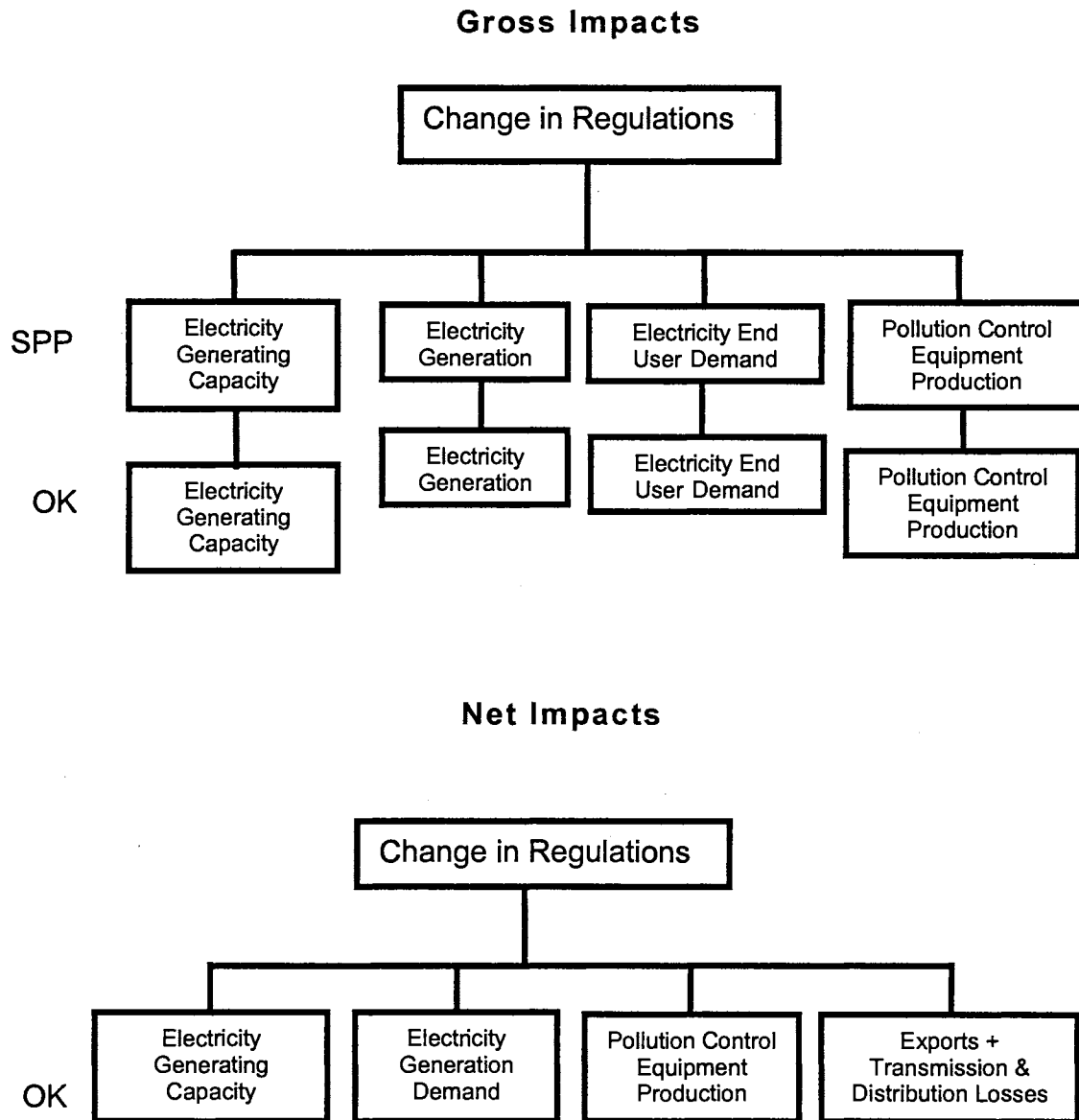
TABLE 4.1

**Expected Direct Effects From Multiple Emissions Regulations
On the Oklahoma Economy**

<u>Principal Items Affected</u>	<u>Expected Effects</u>
coal production	decrease
natural gas & petroleum production	increase
renewable fuels production	increase
coal-fired electricity generation	decrease
natural gas & petroleum-fired electricity generation	increase
renewable energy-fired electricity generation	increase
electricity consumption	decrease
emission control equipment production	increase

FIGURE 4.2

Effects of Multiple Emissions Regulations - Gross and Net Impacts



We need to know the strength, as well as the sign, of each of these effects. Ideally, this will be determined with an interregional general equilibrium model containing detailed energy production and consumption sectors. We do

not believe that such a model currently exists with all of the necessary properties. Thus, it will be necessary to construct and validate a bridge model that links the EIA's projected levels of these variables at the national level to projected impacts in Oklahoma, at the state level.

The bridge model that has been constructed contains a separate component for each of the principal items affected in Table 4.1.

Oklahoma's participating share of 29.86% in the Southwest Power Pool was used to determine the construction, generation, end-use demand, and pollution control equipment manufacturing impacts on the Oklahoma economy. Oklahoma's 29.86 percent participating share within the Southwest Power Pool came from the Energy Information Administration's Washington D.C. office, Mr. Paul Kondis.

Construction of the Oklahoma Bridge Model and Resulting Data

Energy Information Administration electricity projections in the Reference and Advanced Technology Cases from 2000 through 2020 were taken from a key document titled "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants with Advanced Technology Scenarios." These electricity projections represent national values.

From these national values, a regional breakdown was then extracted. Southwest Power Pool values were received from Energy Information Administration headquarters in Washington D.C. from Mr. Paul Kondis, one of the regional directors. Southwest Power Pool regional projections for the

reference and advanced technology cases are shown in appendix A.2. In addition, percentages for all states in the Southwest Power Pool were received from the Energy Information Administration. Oklahoma values were then calculated using 29.86% as Oklahoma's share of capacity from the Southwest Power Pool. Projected values for Oklahoma were calculated for the Reference Case with and without emission limits and for the Advanced Technology Case with and without emission limits. Each case was then evaluated separately, recording the difference between impacts with emission limits and without emission limits for each scenario. The resulting change in the values for each scenario involving new construction, electricity generation, consumption, and pollution control equipment production was then recorded.

The impacts measured included: change in electricity generating capacity (new plant construction), change in electricity generated, change in electricity end-user demands (includes residential, commercial, industrial, and transportation), and change in pollution control equipment production.

Physical measures were then converted to dollar amounts. These dollar values represent the Oklahoma bridge model outputs. These outputs were then used as the direct inputs in the input-output model used to determine impacts on the Oklahoma economy. Oklahoma bridge model output results are shown in tables 4.2, 4.5, 4.6, 4.7, and 4.8.

Electricity Generating Capacity

Under the multiple regulation scenarios, what will be the change in Oklahoma's electricity generating capacity from 2000 through 2020? What new capacity will be from coal and "other", where other equals natural gas, petroleum, and renewables?

Electricity generating capacity (new plant construction) data are shown in table 4.2 and were calculated using the following equation:

$$4.1 \quad \text{Cost of constructing new generating capacity} = \text{change in capacity (MW)} \times \text{price/MW of new capacity}$$

The price used per KWH of new capacity was \$432. This price was taken from a survey done by Dr. Kent Olson of construction costs for gas turbine generating plants, the projected type of new capacity for Oklahoma.⁴⁵ The results of this survey are shown in table 4.3.

Using NEMS information for new power plant construction for the State of Oklahoma, their projection calls for approximately 15,170 MW of new electricity production capacity between 2000-2020. This information was independently verified using Oklahoma Department of Environmental Quality (ODEQ) projections to determine if there were any differences between NEMS projections and power plants likely to be built in Oklahoma.⁴⁶ Capacity that appears to be planned, according ODEQ permit records, totals approximately 15,319 MW of

⁴⁵ Olson, Kent W. "Construction Costs for Gas Turbine Generating Plants, By Year." 1999.

⁴⁶ Oklahoma Department of Environmental Quality, "Power Plants-Permit Status," http://www.deq.state.ok.us/WQDnew/opdes/industrial/power_plants/power_plants.asp.

new electricity production capacity within this same time period. There is less than 1% variation between these two scenarios. The current ODEQ permit record is summarized in table 4.4.

Electricity Generation

Under the multiple regulation scenarios, how much electricity will be generated in Oklahoma from 2000 through 2020? We began determining this by first sorting by fuel types – coal, and “other”, where other equals natural gas, petroleum, and renewables.

Electricity generation data are shown in table 4.5 and were calculated using the following equation:

$$4.2 \quad \text{Change in the value of electricity generation} = \text{change in electricity generated (BKWH)} \times \text{electricity price for Oklahoma (BKWH)}.$$

The price used for Oklahoma was 5.37 cents/KWH. This price was held constant for this forecast.⁴⁷

⁴⁷ Energy Information Administration, “State Electricity Profiles 2001 – Oklahoma,” http://www.eia.doe.gov/cneaf/electricity/st_profiles/oklahoma/ok.html.

TABLE 4.2
Electricity Generating Capacity
(Gigawatts)
(\$ Millions)
Reference and Advanced Technology Case Data
Oklahoma Bridge Model

Case	*2000-2004	*2005-2009	*2010-2014	*2015-2020
Reference case - w/L - coal	6.26	5.78	5.23	4.90
Reference case - w/o-L - coal	6.26	6.28	6.37	6.37
Change	0.00	-0.50	-1.14	-1.47
Dollar value	0.00	-\$216.00	-\$492.40	-\$635.00
Reference case - w/L - other	7.56	8.14	8.88	9.75
Reference case - w/o-L - other	7.01	7.25	7.97	9.18
Change	0.55	0.89	0.91	0.57
Dollar value	\$237.60	\$384.50	\$393.10	\$246.20
Adv. tech. case - w/L - coal	6.26	5.77	5.40	5.37
Adv. tech. case - w/o-L - coal	6.26	6.37	6.66	6.66
Change	0.00	-0.60	-1.26	-1.29
Dollar value	0.00	-\$259.20	-\$544.30	-\$557.30
Adv. tech. case - w/L - other	7.54	8.18	8.80	9.36
Adv. tech. case - w/o-L - other	7.01	7.11	7.50	8.50
Change	0.53	1.07	1.30	0.86
Dollar value	\$229.00	\$462.20	\$561.60	\$371.50

*Represents annual values averaged over the time intervals listed.

TABLE 4.3

Construction Costs for Gas Turbine Generating Plants, By Year

Construction Costs for Gas Turbine Generating Plants, By Year

Company	Plant	Year	MW	Cost \$million	\$ per MW (2000)
Gulf States Utilities	E Baton Rouge	1987	32.2		342
Delmarva Power and Light	Hay Road	1989	230		324
Orlando Utilities Commission	Indian River	1989	75		402
Virginia Electric Power		1990	368		292
Iowa Power	Pleasant Hill	1990	83		535
Atlantic City Electric	Cumberland	1990	91		435
Virginia Electric Power	Darbytown	1990	369		292
Florida Power & Light		1992	460		249
Virginia Electric Power		1992	219		450
Int'l Energy Agency, 1989 Projected Costs	General Estimate	1995	300		180 600
Alabama Power	Greene County	1996	827		258
Wisconsin Power & Light	S Fond Du Lac	1996	86		484
Jersey Central Power & Light	Gilbert	1996	163		331
H.R. Linden, May 1997 Electricity Journal	General Estimate	1997			500
AECI	Nordaway	1999	182		351
AECI	St Francis	2000	250		124 496
AECI	Chouteau	2000	522		230 441
U.S. DOE, Power Engineering Oct 2000	General Estimate	2000	40-150		200
Mexico Federal Electricity Commission	Merida III	2000	484		240 496
Power, March/April 2000	General Estimate	2000			500
IEA in Power January/February 2000	General Estimate	2000			500
AECI-KAMO	Chouteau	2000	530		220 415
Cogentrix	Green Country	2002	800		300 375
Duke	McClain	2002	520		200 385
Kinder Morgan	Jackson, MI	2002	550		250 455
Kinder Morgan	Pulaski City, AR	2002	550		250 455
Associated Electric Cooperative, Inc (AECI)	Holden, Mo	2002	321		125 389
AECI	Stoddard County	2002	100		30 333
Calpine Power	Oakdale	2002	86.4		59 683
Duke Energy	Moss Landing	2002	1080		525 495
Duke Energy	McClain	2002	520		200 385
TECO Power Services/Panda Energy	AR & AZ	2002	4800		1920 418
Cogentrix	Ouachita	2002	816		500 613
Cogentrix	Green Country	2002	800		300 375
Cogentrix	Bogalusa	2002	800		300 375
Cogentrix	Rathdrum, ID	2002	270		150 555
New York Power Authority		2002	520		220 423
Holland Energy LLC	Holland Twnshp, IL	2002	650		250 385
Kinder Morgan Power	Jackson, MI	2002	550		250 455
Duke Energy	Moro Bay	2003	1200		600 500
Panda Energy Intl	Mt Vernon, IL	2003	1070		350 327
Tenaska	Fluvanna City, VA	2003	1800		500 278
PSEG Power LLC	Linden, NJ	2003	1186		590 497
Corr. Date and Cost					0.249
Average Cost/KWH					419.744
Standard Deviation					102.400
Annual Energy Outlook 1999					
Advanced Combustion Turbine - \$350					0.011
Conventional Comb turbine - \$350					433.178
Advanced Gas/Oil Comb Cycle - \$440					101.879
Conv Gas/Oil Comb Cycle - \$472					
					0.044
					432.931
					97.561

TABLE 4.4

**New Electric Power Generating Facilities in Oklahoma
Issued, Technical Review or Proposed**

Company	Plant	County	Location	Permit	Status	Type	MW
AEC 1	Chouteau	Mayes	S10-T20N-R19E	98-270-C	Issued	GT	530
Cogentrix	Groen Country	Tulsa	S4-T17N-R13E	99-010-C	Issued	GT	800
AEP/PSO	Northeastern	Rogers	S4-T22N-R15E	96-288-C	Issued	GT	492
Calpine Corp.	Panda Oneta	Wagoner	S27-T18N-R15E	99-028-C	Issued	GT	1150
ONEOK	Edmond	Logan	S29-T15N-R4W	99-312-C	Issued	GT	320
OG&E	Horseshoe	Oklahoma	S14-T12N-R1E	97-137-C	Issued	GT	90
NRG	McClain Energy	McClain	S35-T10N-R-rW	99-213-C	Issued	GT	520
WFEC Genco	Anadarko	Caddo	S14-T7N-R10W	2000-237-C	Issued	GT	94
Intergen	Redbud	Oklahoma	S17-T14N-R1E	2000-090-C	Issued	GT	1100
Energetix	Thunderbird	Cleveland	S25-T9N-R1E	2000-116-C	Issued	GT	825
Kiowa Power	Kiowa	Pittsburg	S34-T3N-R13E	2000-103-C	Issued	GT	1200
Kinder Morgan	Pittsburg	Pittsburg	S27-T3N-R13E	2000-151-C	Issued	GT	550
Smith Cogen	Lawton Energy	Commanche	S25-T2N-R11W	2000-150-C	Technical Review	GT	600
Smith Cogen	Pocola	Le Flore	S34-T10N-R27E	2000-115-C	Issued	GT	1200
Eagle Energy	Webbers Falls	Muskogee	S19-T13N-R19E	2000-278-C	Issued	GT	850
Tenaska	Seminole	Seminole	S11-T7N-R5E	2001-068-C	Proposed	GT	1200
Energetix	Great Plains	Commanche	S26-T1N-R11W	2001-110-C	Technical Review	GT	600
Mustang	Mustang Energy	Canadian	S36-T12N-R5W	2001-132-C	Issued	GT	310
Mustang	Harrah	Lincoln	S18-T12N-R2C	2001-156-C	Issued	GT	310
Duke	Stephens	Stephens	S32-T2N-R7W	2001-157-C	Issued	GT	620
Energetix	Lawton	Commanche	S31-T2N-R12W	2001-205-C	Issued	GT	308
Genova	Genova	Grady	S1-T6N-R7W	2001-223-C	Issued	GT	550
*ONEOK							550
*KM Power							550

Total 15,319 MW

*Applications are expected for these additional gas turbine fired power plants.

Source: ODEQ, Air Quality Division, 707 N. Robinson, Oklahoma City, OK

TABLE 4.5

**Electricity Generation
(Billion KW Hours)
(\$Millions)
Reference and Advanced Technology Case Data
Oklahoma Bridge Model**

Case	*2000-2004	*2005-2009	*2010-2014	*2015-2020
Reference case - w/L - coal	41.51	34.46	30.35	27.42
Reference case - w/o-L - coal	42.70	46.26	47.01	54.93
Change	-1.19	-11.80	-16.66	-27.51
Dollar value	-\$63.90	-\$633.66	-\$894.64	-\$1,477.29
Reference case - w/L - other	10.23	18.56	25.32	31.31
Reference case - w/o-L - other	9.24	9.62	12.81	17.55
Change	0.99	8.94	12.51	13.76
Dollar value	\$53.16	\$480.08	\$671.79	\$738.91
Adv. tech. case - w/L - coal	41.54	34.71	31.61	36.87
Adv. tech. case - w/o-L - coal	42.69	46.85	48.91	49.06
Change	-1.15	12.14	-17.30	-12.19
Dollar value	-\$61.76	-\$651.92	-\$929.01	-\$654.60
Adv. tech. case - w/L - other	10.05	18.84	24.65	28.59
Adv. tech. case - w/o-L - other	9.13	8.83	10.89	15.82
Change	0.92	10.01	13.76	12.77
Dollar value	\$49.40	\$537.54	\$738.91	\$685.75

*Represents annual values averaged over the time intervals listed.

Electricity End-User Demand

Under the multiple regulation scenarios, what will be Oklahoma's projected electricity end-user needs from 2000 through 2020, where the end-users are from the residential, commercial, industrial, and transportation sectors.

Electricity demand end-user data are shown in tables 4.6 and 4.7 and were calculated using the following equation:

$$4.3 \quad \text{Change in value of end-user demand} = \text{change in electricity end-user demand (BKWH)} \times \text{electricity price for Oklahoma (BKWH)}.$$

The price used for Oklahoma was 5.37 cents/KWH. This price was held constant for this forecast.

TABLE 4.6

**Residential and Commercial Electricity End-User Demand
(Billion KW Hours)
(\$Millions)**

**Reference and Advanced Technology Case Data
Oklahoma Bridge Model**

Case	*2000-2004	*2005-2009	*2010-2014	*2015-2020
Reference case - w/L – res.	18.11	18.96	20.15	21.89
Reference case - w/o-L – res.	18.35	20.17	21.87	23.86
Change	-0.24	-1.21	-1.72	-1.97
Dollar value	-\$12.89	-\$64.98	-\$92.36	-\$105.79
Adv. tech. case - w/L – res.	18.09	19.02	20.19	22.10
Adv. tech. case - w/o-L – res.	18.32	20.08	-21.66	23.62
Change	-0.23	-1.06	-1.47	-1.52
Dollar value	-\$12.35	-\$56.92	-\$78.94	-\$81.62
Reference case - w/L – com.	17.39	18.94	20.66	22.00
Reference case - w/o-L – com.	17.82	20.28	22.61	24.50
Change	-0.43	-1.34	-1.95	-2.50
Dollar value	-\$23.09	-\$71.96	-\$104.72	-\$134.25
Adv. tech. case - w/L – com.	17.41	19.05	20.74	22.28
Adv. tech. case - w/o-L – com.	17.79	20.11	22.29	24.11
Change	-0.38	-1.06	-1.55	-1.83
Dollar value	-\$20.41	-\$56.92	-\$83.24	-\$98.27

*Represents annual values averaged over the time intervals listed.

TABLE 4.7

**Industrial and Transportation Electricity End-User Demand
(Billion KW Hours)**

(\$Millions)

**Reference and Advanced Technology Case Data
Oklahoma Bridge Model**

Case	*2000-2004	*2005-2009	*2010-2014	*2015-2020
Reference case - w/L – ind.	15.50	16.04	16.23	16.74
Reference case - w/o-L – ind.	15.68	16.87	17.94	19.28
Change	-0.18	-0.83	-1.71	-2.54
Dollar value	-\$9.67	-\$44.57	-\$91.83	-\$136.40
Adv. tech. case - w/L – ind.	15.47	15.72	15.76	16.20
Adv. tech. case - w/o-L – ind.	15.63	16.52	17.18	18.25
Change	-0.16	-0.80	-1.42	-2.05
Dollar value	-\$8.59	-\$42.96	-\$76.25	-\$110.09
Reference case - w/L – tran.	0.23	0.33	0.43	0.46
Reference case - w/o-L – tran.	0.23	0.33	0.43	0.46
Change	0.00	0.00	0.00	0.00
Dollar value	0.00	0.00	0.00	0.00
Adv. tech. case - w/L – tran.	0.23	0.34	0.45	0.49
Adv. tech. case - w/o-L – tran.	0.23	0.34	0.45	0.49
Change	0.00	0.00	0.00	0.00
Dollar value	0.00	0.00	0.00	0.00

*Represents annual values averaged over the time intervals listed.

Pollution Control Equipment Production

Under the multiple regulation scenarios, how much pollution control equipment will be produced in Oklahoma from 2000 through 2020, where equipment includes both NO_x and ACI equipment. (Explained Below)

Pollution control equipment production data are shown in table 4.8 and were calculated using the following equation:

4.4 Change in value of pollution control equipment produced = change in quantity of pollution control equipment produced (KW) x average price per KW of capacity for NO_x and ACI equipment.

Key NO_x control systems most often used are selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) systems. For a 500 MW plant, equipment that can remove 80 to 90% of the NO_x costs approximately \$90 per kilowatt of capacity. Therefore, \$90 was the price used per kilowatt of capacity for NO_x removal equipment.

Key activated carbon injection systems cost approximately \$35 per kilowatt of capacity for a typical 500 MW plant. Therefore, \$35 was the price used per kilowatt of capacity for ACI removal equipment.⁴⁸

ACI is a mercury removal technology that involves spraying activated carbon into the flue gas stream. Some of the mercury will bond with the

⁴⁸ Energy Information Administration, "Cost per Kilowatt of Capacity for Nitrogen Oxides and Activated Carbon Injection Control Systems," Personal Communication from Paul Kondis, Washington D.C. Office.

activated carbon which will then be captured by the particulate control device, typically either an electrostatic precipitator or a fabric filter system.

The dollar values in tables 4.2, 4.5, 4.6, 4.7, and 4.8 represent the Oklahoma bridge model outputs, which became the input values that were entered into IMPLAN to determine impacts on the Oklahoma economy, as reported in the next chapter.

TABLE 4.8
Pollution Control Equipment Production
(Gigawatts)
(\$Millions)
Reference and Advanced Technology Case Data
Oklahoma Bridge Model

Case	*2000-2004	*2005-2009	*2010-2014	*2015-2020
Reference case - w/L – NO _x .	0.44	2.08	2.89	2.89
Reference case - w/o-L – NO _x .	0.30	0.79	0.83	0.84
Change	0.14	1.29	2.06	2.05
Dollar value	\$12.60	\$116.10	\$185.40	\$184.50
Reference case - w/L – ACI	0.00	2.23	4.35	4.35
Reference case - w/o-L – ACI.	0.00	0.00	0.00	0.00
Change	0.00	2.23	4.35	4.35
Dollar value	0.00	\$78.05	\$152.25	\$152.25
Adv. tech. case - w/L – NO _x .	0.29	1.89	2.82	2.82
Adv. tech. case - w/o-L – NO _x	0.27	0.79	0.82	0.84
Change	0.02	1.10	2.00	1.98
Dollar value	\$1.80	\$99.00	\$180.00	\$178.20
Adv. tech. case - w/L – ACI.	0.00	3.98	7.32	7.32
Adv. tech. case - w/o-L – ACI.	0.00	0.00	0.00	0.00
Change	0.00	3.98	7.32	7.32
Dollar value	0.00	\$139.30	\$256.20	\$256.20

*Represents annual values averaged over the time intervals listed.

CHAPTER V

EFFECTS OF MULTIPLE EMISSIONS REGULATIONS ON THE OKLAHOMA ECONOMY: INPUT-OUTPUT ANALYSIS FOR OKLAHOMA

Introduction

A major objective of this research is to quantify the net impact of multiple emissions regulations on the Oklahoma economy. This will be done by using the outputs from the bridge model as inputs to the latest available version of the IMPLAN input-output model for Oklahoma to determine effects on Oklahoma's income, output, and employment.

IMPLAN is a static, open, input – output (I -O) model for Oklahoma that quantifies the mutual interrelationships among the various sectors of the Oklahoma economy. The model used in this study is Implan Professional, Version 2.0, Social Accounting and Impact Analysis Software.

This Implan version has two components to it, the software component and the database component. The software component performs the necessary calculations using the study area data to create the models. It also provides an interface for the user to change the region's economic description, create impact scenarios, and introduce changes to the local model.

The database component provides all of the information needed to create regional Implan models. The databases have the ability to incorporate user-supplied data at each stage of the model building process. This provides for a

high degree of flexibility both in terms of geographic coverage (i.e. all Oklahoma counties) and model formulation.⁴⁹

Input-Output Models

Input – output models, including IMPLAN, consist primarily of three major components: a transaction or flow table, a table of direct coefficients or technical coefficients, and a table of interdependence (or direct and indirect coefficients).⁵⁰

The transaction or flow table is a table of purchase and sales transactions between “industries” within a (regional) system and with the outside (imports and exports) organized as a matrix [having rows (sales) and columns (purchases)]. The table of direct coefficients or technical coefficients measures direct (backward) links or effects. The table of interdependence (or direct and indirect coefficients) measures direct and indirect (inter-industry) effects.⁵¹

A basic transaction table is divided into four quadrants as shown in table 5.1.

⁴⁹ Implan Professional, Version 2.0, “Social Accounting and Impact Analysis Software,” 1st Edition, 1999.

⁵⁰ Ali Hamsa, “The Impact of Environmental Regulations on Oklahoma’s Income and Employment,” PhD Dissertation, Oklahoma State University, 1996.

⁵¹ Input-Output, “Analysis of Interdependence Structures: Input-Output,” <http://www.faculty.washington.edu/krumme/207/inputoutput.html>.

TABLE 5.1

Basic Transaction Table

From / To	1	2.....	j.....	n	Y	X
1	X_{11}	$X_{12}.....$	$X_{1j}.....$	X_{1n}	Y_1	X_1
2	X_{21}	$X_{22}.....$	$X_{2j}.....$	X_{2n}	Y_2	X_2
i	X_{i1}	$X_{i2}.....$	$X_{ij}.....$	X_{in}	Y_i	X_i
n	X_{n1}	$X_{n2}.....$	$X_{nj}.....$	X_{nn}	Y_n	X_n
v	V_1	V_2	V_j	V_n		
x	X_1	X_2	X_j	X_n		

This table supports the interrelationships that exist in an economy within a given time period and can be expressed mathematically. The row total for a given sector, X_i stands for the total output for the sector, in other words, the sum of sales to processing sectors X_{ij} and the final demand sectors Y_i . Y_i is the total final demand for the output of the sector in the i^{th} row and includes individual consumption expenditures, gross private investment, net exports, and government purchases. The row total (X_i) is equivalent to the total demand (both intermediate and final).

$$(1) \quad X_i = \sum_{j=1}^n x_{ij} + Y_i$$

The column total for a given sector, X_j , stands for the total outlay for a given sector, that is, the sum of purchases from the processing sectors X_{ij} , and

the sum of payments to the primary inputs (V_j), or value added. The primary inputs include payments to labor and proprietors' income along with other elements. The sum of the column entries (X_j) is equivalent to the total cost of production.

$$(2) \quad X_j = \sum_{i=1}^n x_{ij} + V_j$$

Because all the transactions are given in dollar amounts, the row totals are identically equal to the column sums.

$$(3) \quad X_j = \sum_{i=1}^n x_{ij} + V_j = \sum_{j=1}^n x_{ij} + Y_i = X_i \quad (\text{for } i=j)$$

here n denotes the number of industries or sectors in the economy. From equation (3), it follows that

$$(4) \quad \sum_{j=1}^n V_j = \text{GSP}$$

which is the state income accounting identity showing that aggregate income equals aggregate expenditures (GSP is Gross State Product).

The equation for calculating Direct Coefficients (a_{ij}) is

$$a_{ij} = \frac{X_{ij}}{X_j}$$

which equals the amount of industry i 's output necessary to produce one unit of industry j 's output. Direct Coefficients are computed for each industry in the processing sector resulting in the direct coefficient table denoted by the 'A' matrix.

The calculations of direct and indirect coefficients will result in a table of direct and indirect requirements for each dollar of final demand. They are obtained by subtracting the matrix of direct coefficients from an identity matrix of the same order to get the Leontief matrix $(I-A)$, and then inverting that matrix. The resulting matrix, $(I-A)^{-1}$, is the table of direct and indirect coefficients. Therefore, the input-output drill is that of determining the interindustry transactions or output that is required to sustain a given level of final demand.

The solution of the input-output model can be obtained by rewriting equation (1) as

$$(5) \quad X_j = \sum_{i=1}^n a_{ij} X_i + Y_j$$

If X represents a column vector of total output, A represents the direct coefficients matrix, and Y represents the column vector of final demand, then

$$(6) \quad \begin{array}{lcl} X & = & AX + Y \\ Y & = & [I - A] X \end{array}$$

Using the identity matrix and applying matrix algebra, both sides of equation (6) can be multiplied by the inverse $(I-A)$, then

$$(7) \quad X = Y (I - A)^{-1}$$

Where

X = total output sectors of the economy

Y = final demand sectors

The basic tools of the input-output model will be used primarily to estimate productive requirements resulting from changes in final demand, where the changes in final demand are produced by the bridge model. Such backward linkages are the standard fare of input-output analysis. We will examine the possibility of forward linkages, as well, and incorporate them in the analysis, as appropriate.

Multipliers will be used to measure economic impacts resulting from these changes in final demand. A multiplier is a number or coefficient that predicts the sum of all changes throughout the economy caused by a change in a single sector of that economy. Income, output, and employment multipliers are the most commonly used multipliers in input-output analysis. These sets of multipliers recognize that the total impact on the economy will differ depending on which sectors experience the direct change.

Output Multiplier

Output multipliers consist of the column totals of the direct and indirect coefficients table. Therefore, the output multiplier for a certain industry named at the top of the column is equal to the sum of the direct and indirect requirements from all industries needed for the delivery of an additional one-dollar of output by the industry to some final demand. There are Type I and Type II output multipliers. A Type I output multiplier measures the sum of direct and indirect effects. A Type II output multiplier measures direct, indirect, and induced effects from a one-dollar change in the final demand for the output of that sector. The Type I output multiplier is derived by summing the column entries of the direct and indirect matrix $(I-A)^{-1}$, while the Type II output multiplier looks at the effects of consumer spending in addition to the direct and indirect inter-industry effects. Because of the additional impact from the household sector, each Type II output multiplier is expected to be greater than the Type I output multiplier.

Income Multiplier

The income multiplier measures the total change in income throughout the economy that results from a one-dollar variation in income in a particular industry. Both Type I and Type II income multipliers are calculated from the direct, indirect, and induced income effects estimated in the input-output model. The basis of the income multiplier is that a given amount of income is generated with each change in output. The direct income effect is equal to the sum of each dollar of output that goes to households in the form of income, either as wages

and salaries, proprietor income, rents or profits. The Type I income multiplier is equal to the ratio of direct and indirect income effects, to direct income effects resulting from sector changes in the final demand. The Type II income multiplier is equal to the ratio of direct, indirect, and induced income effects based on a per unit change in final demand from a given sector. It is computed for an input-output sector by dividing the household row entry in that particular sector's column of inverse coefficients by the direct income coefficients for that sector.

Employment Multiplier

Employment multipliers identify the change in total employment in the economy that results from a one-unit change in the employment for a particular sector. The Type I employment multiplier measures direct and indirect effects, while the Type II employment multiplier goes an additional step within the chain of interdependencies by estimating direct, indirect, and induced effects. The induced effect comes from the additional reverberations in the economy that are generated by the impacts on household incomes and expenditures.

Implan Tables and Resulting Economic Impacts

The following input-output tables derived from the Implan model reflect the effect of multiple emissions regulations on Oklahoma's economy. The input-output impacts were initiated using the outputs from the bridge model discussed in chapter IV. The following tables focus on effects attributable to direct impacts on electricity generating capacity (new plant construction); electricity generation; electricity demand categorized by end-user (includes residential, commercial,

industrial, and transportation), and pollution control equipment production and are shown in tables 5.3 through 5.30.

The model first had to be aggregated to its final form before the impacts could be determined. The aggregation step is the process of combining Implan sectors by adding together the values represented by those sectors. The aggregated sectors used in the model were categorized into 6 major sectors: sector 1 represents industrial activity, sector 50 represents new utility construction, sector 334 represents pollution control equipment, sector 433 represents transportation activity, sector 441 represents commercial activity, and sector 443 represents electricity generation by fuel type. These aggregated sectors are shown in table 5.2, along with the implan sectors that went into the aggregation.

Table 5.2

Aggregated Sectors



Template: Aggregation #1

Oklahoma Bridge Model - #5 - 10.03.02.iap

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Aggregated Sector Name				: Composed of											
1 Industrial															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	
46	47	48	49	51	52	53	54	55	56	57	58	59	60	61	
62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	
77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	
92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	
107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	
122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	
137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	
152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	
167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	
182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	
197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	
212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	
227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	
242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	
272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	
287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	
302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	
317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	
332	333	335	336	338	339	340	341	342	343	344	345	346	347	348	
350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	
365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	
380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	
395	396	397	398	399	400	401	402	404	405	406	407	408	409	410	
411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	
426	427	428	429	430	431	432									
50 New Utility Const.															
50															
334 Pollution Control Eq.															
334	337	349	403												
433 Transportation															
433	434	435	436	437	438	439	440								
441 Commercial															
441	442	444	445	446	447	448	449	450	451	452	453	454	455	456	
457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	
472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	
487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	
502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	
517	518	519	520	521	522	523	524	525	526	527	528				
443 Electric Utilities															
443															

The electricity generating capacity section (new utility plant construction) used sector 50 for building the events tables. The resulting economic impacts for the reference case and the advanced technology case are shown in tables 5.4, 5.5, 5.7, and 5.8.

These projections represent the total value added impacts, labor income impacts, employment impacts, and output impacts on the Oklahoma economy and represents annual values averaged over four time intervals from 2000 through 2020. Numbers are in millions of dollars except for employment. Employment represents actual numbers.

Tables 5.3 and 5.6 summarize the impacts (direct, indirect, and induced) from changes in electricity generating capacity from 2000 through 2020 for the reference and advanced technology cases respectively.

The results indicate that electric capacity will decrease for coal under both the reference case and the advanced technology case, while natural gas, petroleum, and renewable capacity will increase.

It should be noted that the negative values in tables 5.3, 5.4, 5.6, and 5.7 (impacts: direct, indirect, and induced from changes in electricity generating capacity – 2000-2020 reference and advanced technology cases, reference case – coal, and advanced technology case – coal) indicates a reduced demand on Oklahoma inputs for coal. These tables do not represent a negative construction impact. Construction impacts are accounted for in tables 5.3, 5.5, 5.6, and 5.8 (reference and advanced technology cases – “other”), where “other” stands for natural gas, petroleum, and renewables.

ODEQ has issued several permits for new state-of-the-art gas turbine power plants. Depending on what happens with the multiple emissions regulations, will determine how fast and how many of these plants will be built.

TABLE 5.3

**Sum of the Total Impacts (Direct, Indirect, and Induced) from Changes in Electricity Generating Capacity – 2000 through 2020
(\$Millions, Number Employed)
Reference Case**

Totals	Amount
Change in Value Added	-\$1,800.47
Coal	-\$8,164.7
Other	\$6,364.30
Change in Labor Income	-\$1,418.75
Coal	-\$6,170.05
Other	\$4,751.30
Change in Employment	-49,867.1
Coal	-216,867.3
Other	167,002.2
Change in Output	-\$3,576.96
Coal	-\$15,555.90
Other	\$11,976.94

TABLE 5.4
Electricity Generating Capacity
(Gigawatts)
Reference Case - Coal
Impacts

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	0.00	-107.21	-244.44	-315.20
Indirect	0.00	-58.36	-133.07	-171.59
Induced	0.00	-77.22	-176.06	-227.03
Total	0.00	-242.80	-533.57	-713.82
<u>Labor Income</u>				
Direct	0.00	-94.39	-215.22	-277.51
Indirect	0.00	-37.60	-85.73	-110.55
Induced	0.00	-49.27	-122.33	-144.82
Total	0.00	-181.26	-413.27	-532.90
<u>Employment</u>				
Direct	0.00	-3,081.4	-7,025.5	-9,059.2
Indirect	0.00	-1,417.3	-3,231.5	-4,166.9
Induced	0.00	-1,872.3	-4,268.9	-5,504.7
Total	0.00	-6,371.0	-14,525.9	-18,730.8
<u>Output</u>				
Direct	0.00	-250.00	-570.00	-735.00
Indirect	0.00	-91.30	-280.15	-268.41
Induced	0.00	-115.69	-263.78	-340.14
Total	0.00	-456.99	-1,041.93	-1,343.55

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.5**Electricity Generating Capacity
(Gigawatts)****Reference Case – N. Gas, Petroleum, and Renewables
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	101.89	164.89	168.58	105.58
Indirect	55.47	89.76	91.77	57.46
Induced	73.39	118.77	121.42	76.05
Total	230.75	373.42	381.77	239.10
<u>Labor Income</u>				
Direct	89.71	145.18	148.42	92.96
Indirect	35.74	57.83	59.12	37.03
Induced	46.82	75.77	77.47	48.52
Total	172.27	278.78	285.01	178.50
<u>Employment</u>				
Direct	2,928.5	4,739.1	4,845.1	3,034.5
Indirect	1,347.0	2,179.8	2,228.6	1,395.8
Induced	1,779.5	2,879.7	2,944.1	1,843.9
Total	6,055.0	9,798.6	10,017.8	6,274.2
<u>Output</u>				
Direct	237.60	384.50	393.10	246.20
Indirect	86.77	140.41	143.55	89.91
Induced	109.95	177.94	181.92	113.93
Total	434.32	702.85	718.57	450.04

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.6

**Sum of the Total Impacts (Direct, Indirect, and Induced) from Changes in
Electricity Generating Capacity – 2000 through 2020
(\$Millions, Number Employed)
Advanced Technology Case**

Totals	Amount
Change in Value Added	-\$26.22
Coal	-\$8,274.41
Other	\$8,248.19
Change in Labor Income	-\$19.65
Coal	-\$6,177.35
Other	\$6,157.70
Change in Employment	-688.4
Coal	-217,123.7
Other	216,435.3
Change in Output	-\$49.29
Coal	-\$15,574.18
Other	\$15,524.89

TABLE 5.7**Electricity Generating Capacity
(Gigawatts)****Advanced Technology Case - Coal
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	0.00	-128.65	-270.17	-276.60
Indirect	0.00	-70.04	-147.08	-150.58
Induced	0.00	-92.67	-194.60	-199.23
Total	0.00	-291.35	-611.84	-626.41
<u>Labor Income</u>				
Direct	0.00	-113.27	-237.87	-243.53
Indirect	0.00	-45.12	-94.75	-97.01
Induced	0.00	-59.12	-124.15	-127.11
Total	0.00	-217.51	-456.78	-467.65
<u>Employment</u>				
Direct	0.00	3,697.6	-7,765.0	-7,949.9
Indirect	0.00	-1,700.8	-3,571.6	-3,656.7
Induced	0.00	-2,246.8	-4,718.3	-4,830.6
Total	0.00	-7,645.2	-16,054.9	-16,437.2
<u>Output</u>				
Direct	0.00	-300.00	-630.00	-645.00
Indirect	0.00	-109.56	-230.07	-235.54
Induced	0.00	-138.83	-291.55	-298.49
Total	0.00	-548.39	-1,151.61	-1,179.03

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.8**Electricity Generating Capacity
(Gigawatts)****Advanced Technology Case – N. Gas, Petroleum, and Renewables
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	98.21	198.21	240.84	159.32
Indirect	53.46	107.90	131.11	86.73
Induced	70.73	142.77	173.47	114.75
Total	222.40	448.88	545.41	360.79
<u>Labor Income</u>				
Direct	86.46	174.51	212.04	140.27
Indirect	34.44	69.52	84.47	55.88
Induced	45.13	91.08	110.67	73.21
Total	166.03	335.11	407.18	269.35
<u>Employment</u>				
Direct	2,822.5	5,696.8	6,922.0	4,578.9
Indirect	1,298.3	2,620.3	3,183.9	2,106.1
Induced	1,715.1	3,461.6	4,206.0	2,782.3
Total	5,835.8	11,778.7	14,311.8	9,467.3
<u>Output</u>				
Direct	229.00	462.20	561.60	371.50
Indirect	83.63	168.79	205.09	135.67
Induced	105.97	213.89	259.89	171.92
Total	418.61	844.88	1,026.58	679.09

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

The electricity generation section used sector 443 for building the events tables. The resulting economic impacts for the reference case and the advanced technology case are shown in tables 5.10, 5.11, 5.13, and 5.14.

These projections represent the total value added impacts, labor income impacts, employment impacts, and output impacts on the Oklahoma economy and represents annual values averaged over four time intervals from 2000 through 2020. Numbers are in millions of dollars except for employment. Employment represents actual numbers.

Tables 5.9 and 5.12 summarize the impacts (direct, indirect, and induced) from changes in electricity generation from 2000 through 2020 for the reference and advanced technology cases respectively.

The results indicate that electricity generation will decrease for coal under both the reference case and the advanced technology case, while natural gas, petroleum, and renewable electricity generation will increase.

TABLE 5.9

**Sum of the Total Impacts (Direct, Indirect, and Induced) from Changes in
Electricity Generation– 2000 through 2020
(\$Millions, Number Employed)
Reference Case**

Totals	Amount
Change in Value Added	-\$6,482.18
Coal	-\$17,131.52
Other	\$10,649.34
Change in Labor Income	-\$2,074.00
Coal	-\$5,481.22
Other	\$3,407.22
Change in Employment	-45,933.6
Coal	-121,396.1
Other	75,462.5
Change in Output	-\$8,382.05
Coal	-\$22,152.71
Other	\$13,770.66

TABLE 5.10**Electricity Generation
(Billion KW Hours)****Reference Case – Coal
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	-51.92	-514.79	-726.81	-1,200.16
Indirect	-4.28	-42.48	-59.97	-99.03
Induced	-8.87	-87.95	-124.17	-205.03
Total	-65.07	-645.21	-910.96	-1,504.22
<u>Labor Income</u>				
Direct	-12.41	-123.03	-173.70	-286.83
Indirect	-2.75	-27.30	-38.54	-63.64
Induced	-5.66	-56.11	-79.22	-130.81
Total	-20.82	-206.44	-291.46	-481.27
<u>Employment</u>				
Direct	-145.0	-1,438.1	-2,030.4	-3,352.7
Indirect	-101.0	-1,001.6	-1,414.1	-2,335.1
Induced	-215.0	-2,132.4	-3,010.6	-4,971.3
Total	-461.1	-4,572.1	-6,455.1	-10,659.1
<u>Output</u>				
Direct	-63.90	-633.66	-894.64	-1,477.29
Indirect	-6.95	-68.90	-97.28	-160.64
Induced	-13.29	-131.76	-186.03	-307.18
Total	-84.14	-834.32	-1,177.95	-1,945.11

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.11

**Electricity Generation
(Billion KW Hours)
Reference Case – N. Gas, Petroleum, and Renewables
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	43.19	390.02	545.77	600.30
Indirect	3.56	32.18	54.03	49.53
Induced	7.38	66.63	93.24	102.55
Total	54.13	488.83	684.04	752.39
<u>Labor Income</u>				
Direct	10.32	93.21	130.43	143.47
Indirect	2.29	20.68	28.94	31.83
Induced	4.71	42.51	59.48	65.43
Total	17.32	156.40	218.86	240.72
<u>Employment</u>				
Direct	120.7	1,089.5	1,524.6	1,677.0
Indirect	84.0	758.8	1,061.9	1,168.0
Induced	178.9	1,615.6	2,260.7	2,486.6
Total	383.6	3,463.9	4,847.2	5,331.5
<u>Output</u>				
Direct	53.16	480.08	671.79	738.91
Indirect	5.78	52.20	73.05	80.35
Induced	11.05	99.83	139.69	153.65
Total	70.00	632.11	884.53	972.91

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.12

**Sum of the Total Impacts (Direct, Indirect, and Induced) from Changes in
Electricity Generation-- 2000 through 2020
(\$Millions, Number Employed)
Advanced Technology Case**

Totals	Amount
Change in Value Added	-\$1,422.74
Coal	-\$12,362.39
Other	\$10,939.65
Change in Labor Income	-\$455.26
Coal	-\$3,955.31
Other	\$3,500.05
Change in Employment	-10,081.8
Coal	-87,601.7
Other	77,519.9
Change in Output	-\$1,839.69
Coal	-\$15,985.75
Other	\$14,146.06

TABLE 5.13
Electricity Generation
(Billion KW Hours)
Advanced Technology Case – Coal
Impacts

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	-50.17	-529.62	-754.74	-531.81
Indirect	-4.14	-43.70	-62.28	-43.88
Induced	-8.57	-90.48	-128.94	-90.85
Total	-62.88	-663.80	-945.95	-666.54
<u>Labor Income</u>				
Direct	-11.99	-126.57	-180.37	-127.10
Indirect	-2.66	-28.08	-40.02	-28.12
Induced	-5.47	-57.73	-82.26	-57.96
Total	-20.12	-212.38	-302.65	-213.26
<u>Employment</u>				
Direct	-140.2	-1,479.5	-2,108.4	-1,485.6
Indirect	-97.6	-1,030.4	-1,468.4	-1,034.7
Induced	-207.8	-2,193.8	-3,126.3	-2,202.9
Total	-445.6	-4,703.8	-6,703.1	-4,723.2
<u>Output</u>				
Direct	-61.76	-651.92	-929.01	-654.60
Indirect	-6.72	-70.89	-101.02	-71.18
Induced	-12.84	-135.56	-193.18	-136.12
Total	-81.31	-858.36	-1,223.20	-861.90

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.14

**Electricity Generation
(Billion KW Hours)
Advanced Technology--- Case – N. Gas, Petroleum, and Renewables
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	40.04	436.70	600.30	557.11
Indirect	3.31	36.03	49.53	45.97
Induced	6.86	74.61	102.55	95.18
Total	50.30	547.34	752.39	698.25
<u>Labor Income</u>				
Direct	9.59	104.37	143.47	133.14
Indirect	2.13	23.16	31.83	29.54
Induced	4.37	47.60	65.43	60.72
Total	16.09	175.12	240.72	223.40
<u>Employment</u>				
Direct	112.1	1,219.9	1,677.0	1,556.3
Indirect	78.1	849.7	1,168.0	1,083.9
Induced	166.3	1,808.9	2,486.6	2,307.7
Total	356.5	3,878.5	5,331.5	4,947.9
<u>Output</u>				
Direct	49.40	537.54	738.91	685.75
Indirect	5.37	58.45	80.35	74.57
Induced	10.27	111.77	153.65	142.59
Total	65.05	707.76	972.91	902.91

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

The electricity end-user demand section used the majority of the sectors for building the events tables. Sections 1, 433, 441, and a separate stand-alone external residential sector, sector 10008, were used for building the events tables. The resulting economic impacts for the reference case and the advanced technology case are shown in tables 5.16 through 5.19, and 5.21 through 5.24.

These projections represent the total value added impacts, labor income impacts, employment impacts, and output impacts on the Oklahoma economy and represents annual values averaged over four time intervals from 2000 through 2020. Numbers are in millions of dollars except for employment. Employment represents actual numbers.

Tables 5.15 and 5.20 summarize the impacts (direct, indirect, and induced) from changes in electricity end-user demand from 2000 through 2020 for the reference and advanced technology cases respectively.

The results indicate that electricity end-user demand will decrease for coal under both the reference case and the advanced technology case, while natural gas, petroleum, and renewable generation demand will increase. In the advanced technology case, electricity generation will exceed end-user demand; therefore, indicating that Oklahoma will become a net exporter of electricity as power producers incorporate advanced technologies.

TABLE 5.15

**Sum of the Total Impacts (Direct, Indirect, and Induced) from Changes in
Electricity End-User Demand – 2000 through 2020
(\$Millions, Number Employed)
Reference Case**

Totals	Amount
Change in Value Added	-\$4,468.60
Residential	-\$1,144.81
Commercial	-\$2,132.63
Industrial	-\$1,191.16
Transportation	0.00
Change in Labor Income	-\$2,850.39
Residential	-\$731.80
Commercial	-\$1,378.95
Industrial	-\$739.64
Transportation	0.00
Change in Employment	-105,988.2
Residential	-27,832.6
Commercial	-53,132.8
Industrial	-25,022.8
Transportation	0.0
Change in Output	-\$7,862.56
Residential	-\$2,208.11
Commercial	-\$3,138.90
Industrial	-\$2,515.55
Transportation	0.00

TABLE 5.16

**Electricity End-User Demand
(Billion KW Hours)
Reference Case – Residential
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	-5.77	-29.09	-41.35	-47.36
Indirect	-1.45	-7.34	-10.43	-11.95
Induced	-2.70	-13.63	-19.38	-22.20
Total	-9.93	-50.06	-71.16	-81.51
<u>Labor Income</u>				
Direct	-3.69	-18.60	-26.44	-30.29
Indirect	-0.93	-4.70	-6.68	-7.65
Induced	-1.73	-8.70	-12.36	-14.16
Total	-6.35	-32.00	-45.49	-52.10
<u>Employment</u>				
Direct	-140.6	-708.8	-1,007.5	-1,153.9
Indirect	-35.3	-177.8	-252.8	-289.5
Induced	-65.6	-330.6	-469.9	-538.2
Total	-241.4	-1,217.1	-1,730.1	-1,981.6
<u>Output</u>				
Direct	-12.88	-64.98	-92.36	-105.79
Indirect	-2.21	-11.12	-15.86	-18.17
Induced	-4.05	-20.43	-29.04	-33.26
Total	-19.15	-96.56	-137.26	-157.21

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.17

**Electricity End-User Demand
(Billion KW Hours)
Reference Case – Commercial
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	-15.92	-49.60	-72.18	-92.53
Indirect	-3.86	-12.03	-17.50	-22.44
Induced	-7.52	-23.43	-34.09	-43.71
Total	-27.29	-85.05	-123.77	-158.68
<u>Labor Income</u>				
Direct	-10.38	-32.33	-47.05	-60.32
Indirect	-2.48	-7.71	-11.23	-14.39
Induced	-4.80	-14.95	-21.75	-27.89
Total	-17.65	-54.99	-80.03	-102.60
<u>Employment</u>				
Direct	-403.5	-1,257.4	-1,829.8	-2,345.9
Indirect	-94.2	-293.5	-427.2	-547.7
Induced	-182.3	-568.1	-826.7	-1,059.8
Total	-680.0	-2,119.0	-3,083.6	-3,953.3
<u>Output</u>				
Direct	-23.09	-71.96	-104.72	-134.25
Indirect	-5.82	-18.12	-26.37	-33.81
Induced	-11.26	-35.10	-51.08	-65.49
Total	-40.17	-125.18	-182.17	-233.55

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.18

**Electricity End-User Demand
(Billion KW Hours)
Reference Case – Industrial
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	-3.59	-16.55	-34.10	-50.65
Indirect	-1.88	-8.66	-17.84	-26.51
Induced	-1.97	-9.07	-18.68	-27.75
Total	-7.43	-34.28	-70.63	-104.91
<u>Labor Income</u>				
Direct	-2.17	-10.03	-20.66	-30.69
Indirect	-1.19	-5.47	-11.27	-16.75
Induced	-1.25	-5.79	-11.92	-17.70
Total	-4.62	-21.29	-43.85	-65.14
<u>Employment</u>				
Direct	-65.2	-300.5	-619.2	-919.7
Indirect	-43.3	-199.7	-411.5	-611.2
Induced	-47.7	-219.9	-453.0	-672.9
Total	-156.2	-720.1	-1,483.7	-2,203.8
<u>Output</u>				
Direct	-9.67	-44.57	-91.83	-136.40
Indirect	-3.09	-14.24	-29.33	-43.57
Induced	-2.95	-13.56	-27.99	-41.58
Total	-15.70	-72.40	-149.15	-221.55

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.19

**Electricity End-User Demand
(Billion KW Hours)
Reference Case – Transportation
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	0.00	0.00	0.00	0.00
Indirect	0.00	0.00	0.00	0.00
Induced	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00
<u>Labor Income</u>				
Direct	0.00	0.00	0.00	0.00
Indirect	0.00	0.00	0.00	0.00
Induced	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00
<u>Employment</u>				
Direct	0.00	0.00	0.00	0.00
Indirect	0.00	0.00	0.00	0.00
Induced	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00
<u>Output</u>				
Direct	0.00	0.00	0.00	0.00
Indirect	0.00	0.00	0.00	0.00
Induced	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.20

**Sum of the Total Impacts (Direct, Indirect, and Induced) from Changes in
Electricity End-User Demand – 2000 through 2020
(\$Millions, Number Employed)
Advanced Technology Case**

Totals	Amount
Change in Value Added	-\$3,593.72
Residential	-\$948.34
Commercial	-\$1,645.86
Industrial	-\$999.52
Transportation	0.00
Change in Labor Income	-\$2,290.97
Residential	-\$606.20
Commercial	-\$1,064.15
Industrial	-\$620.62
Transportation	0.00
Change in Employment	-85,057.6
Residential	-23,056.0
Commercial	-41,004.4
Industrial	-20,997.2
Transportation	0.0
Change in Output	-\$6,362.27
Residential	-\$1,829.05
Commercial	-\$2,422.36
Industrial	-\$2,110.86
Transportation	0.00

TABLE 5.21

**Electricity End-User Demand
(Billion KW Hours)
Advanced Technology Case – Residential
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	-5.53	-25.48	-35.34	-36.54
Indirect	-1.39	-6.43	-8.91	-9.22
Induced	-2.59	-11.94	-16.56	-17.13
Total	-9.52	-43.86	-60.82	-62.89
<u>Labor Income</u>				
Direct	-3.54	-16.30	-22.60	-23.37
Indirect	-0.89	-4.12	-5.71	-5.91
Induced	-1.65	-7.62	-10.57	-10.93
Total	-6.08	-28.04	-38.88	-40.20
<u>Employment</u>				
Direct	-134.7	-620.9	-861.1	-890.3
Indirect	-33.8	-155.8	-216.0	-223.4
Induced	-62.8	-289.6	-401.6	-415.3
Total	-231.4	-1,066.3	-1,478.7	-1,529.0
<u>Output</u>				
Direct	-12.36	-56.92	-78.94	-81.62
Indirect	-2.12	-9.78	-13.56	-14.02
Induced	-3.88	-17.89	-24.82	-25.66
Total	-18.35	-84.59	-117.31	-121.30

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.22

**Electricity End-User Demand
(Billion KW Hours)
Advanced Technology Case – Commercial
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	-14.04	-39.23	-57.37	-67.73
Indirect	-3.41	-9.51	-13.91	-16.43
Induced	-6.64	-18.53	-27.10	-31.99
Total	-24.12	-67.28	-98.38	-116.16
<u>Labor Income</u>				
Direct	-9.17	-25.58	-37.40	-44.16
Indirect	-2.19	-6.10	-8.92	-10.53
Induced	-4.24	-11.82	-17.29	-20.41
Total	-15.60	-43.50	-63.61	-75.10
<u>Employment</u>				
Direct	-356.6	-994.6	-1,454.4	-1,717.2
Indirect	-83.2	-232.2	-339.5	-400.9
Induced	-161.1	-449.4	-657.1	-775.8
Total	-600.9	-1,676.2	-2,451.1	-2,893.9
<u>Output</u>				
Direct	-20.41	-56.92	-83.24	-98.27
Indirect	-5.14	-14.33	-20.96	-24.75
Induced	-9.95	-27.77	-40.60	-47.94
Total	-35.50	-99.02	-144.80	-170.96

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.23

**Electricity End-User Demand
(Billion KW Hours)
Advanced Technology Case – Industrial
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	-3.19	-15.95	-28.32	-40.88
Indirect	-1.67	-8.35	-14.82	-21.39
Induced	-1.75	-8.74	-15.51	-22.40
Total	-6.61	-33.04	-58.65	-84.67
<u>Labor Income</u>				
Direct	-1.93	-9.67	-17.16	-24.77
Indirect	-1.05	-5.24	-9.36	-13.52
Induced	-1.12	-5.58	-9.90	-14.29
Total	-4.10	-20.52	-36.42	-52.57
<u>Employment</u>				
Direct	-57.9	-289.7	-514.2	-742.3
Indirect	-38.5	-192.5	-341.7	-493.3
Induced	-42.4	-211.9	-376.2	-543.1
Total	-138.8	-694.1	-1,232.1	-1,778.7
<u>Output</u>				
Direct	-8.59	-42.96	-76.25	-110.09
Indirect	-2.74	-13.72	-24.36	-35.17
Induced	-2.62	-13.09	-23.24	-33.56
Total	-13.96	-69.78	-123.86	-178.81

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.24

**Electricity End-User Demand
(Billion KW Hours)
Advanced Technology Case – Transportation
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	0.00	0.00	0.00	0.00
Indirect	0.00	0.00	0.00	0.00
Induced	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00
<u>Labor Income</u>				
Direct	0.00	0.00	0.00	0.00
Indirect	0.00	0.00	0.00	0.00
Induced	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00
<u>Employment</u>				
Direct	0.00	0.00	0.00	0.00
Indirect	0.00	0.00	0.00	0.00
Induced	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00
<u>Output</u>				
Direct	0.00	0.00	0.00	0.00
Indirect	0.00	0.00	0.00	0.00
Induced	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

The pollution control equipment production section used sector 334 for building the events tables. The resulting economic impacts for the reference case and the advanced technology case are shown in tables 5.26, 5.27, 5.29, and 5.30.

These projections represent the total value added impacts, labor income impacts, employment impacts, and output impacts on the Oklahoma economy and represents annual values averaged over four time intervals from 2000 through 2020. Numbers are in millions of dollars except for employment. Employment represents actual numbers.

Tables 5.25 and 5.28 summarize the impacts (direct, indirect, and induced) from changes in pollution control equipment production from 2000 through 2020 for the reference and advanced technology cases respectively.

The results indicate that pollution control equipment manufacturing will increase under both the reference case and the advanced technology case, for coal, natural gas, petroleum, and renewables. It also indicates that Oklahoma will become a net exporter of pollution control equipment, and that Oklahoma should be able to capture an increased market share of this industry.

TABLE 5.25

**Sum of the Total Impacts (Direct, Indirect, and Induced) from Changes in
Pollution Control Equipment Production – 2000 through 2020
(\$Millions, Number Employed)
Reference Case**

Totals	Amount
Change in Value Added	\$4,075.65
NO _x	\$2,301.01
ACI	\$1,774.64
Change in Labor Income	\$3,030.76
NO _x	\$1,711.06
ACI	\$1,319.70
Change in Employment	88,517.3
NO _x	49,974.6
ACI	38,542.7
Change in Output	\$8,096.13
NO _x	\$4,570.92
ACI	\$3,525.21

TABLE 5.26

**Pollution Control Equipment Production
(Gigawatts)
Reference Case – NO_x
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	5.07	46.78	74.70	74.34
Indirect	2.32	21.39	34.15	33.98
Induced	3.43	31.61	50.48	50.23
Total	10.83	99.77	159.33	158.56
<u>Labor Income</u>				
Direct	4.39	40.47	64.63	64.32
Indirect	1.47	13.56	21.65	21.54
Induced	2.19	20.17	32.20	32.05
Total	8.05	74.19	118.48	117.91
<u>Employment</u>				
Direct	97.7	899.8	1,436.9	1,429.9
Indirect	54.3	500.8	799.7	795.8
Induced	83.2	766.4	1,223.9	1,217.9
Total	235.2	2,167.0	3,460.4	3,443.6
<u>Output</u>				
Direct	12.60	116.10	185.40	184.50
Indirect	3.77	34.74	55.48	55.21
Induced	5.14	47.36	75.62	75.26
Total	21.51	198.20	316.51	314.97

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.27

**Pollution Control Equipment Production
(Gigawatts)
Reference Case – ACI
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	0.00	31.45	61.35	61.35
Indirect	0.00	14.38	28.04	28.04
Induced	0.00	21.25	41.45	41.45
Total	0.00	67.08	130.84	130.84
<u>Labor Income</u>				
Direct	0.00	27.21	53.08	53.08
Indirect	0.00	9.11	17.78	17.78
Induced	0.00	13.56	26.45	26.45
Total	0.00	49.88	97.30	97.30
<u>Employment</u>				
Direct	0.00	604.9	1,179.9	1,179.9
Indirect	0.00	336.7	656.7	656.7
Induced	0.00	515.2	1,005.0	1,005.0
Total	0.00	1,456.8	2,841.7	2,841.7
<u>Output</u>				
Direct	0.00	78.05	152.25	152.25
Indirect	0.00	23.36	45.56	45.56
Induced	0.00	31.84	62.10	62.10
Total	0.00	133.24	259.91	259.91

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.28

**Sum of the Total Impacts (Direct, Indirect, and Induced) from Changes in
Pollution Control Equipment Production – 2000 through 2020
(\$Millions, Number Employed)
Advanced Technology Case**

Totals	Amount
Change in Value Added	\$5,145.86
NO _x	\$2,125.44
ACI	\$3,020.42
Change in Labor Income	\$3,826.66
NO _x	\$1,580.53
ACI	\$2,246.13
Change in Employment	111,761.9
NO _x	46,161.0
ACI	65,600.9
Change in Output	\$10,222.23
NO _x	\$4,222.11
ACI	\$6,000.12

TABLE 5.29

**Pollution Control Equipment Production
(Gigawatts)
Advanced Technology Case – NO_x
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	0.72	39.89	72.53	71.80
Indirect	0.33	18.24	33.16	32.82
Induced	0.49	26.95	49.01	48.52
Total	1.55	85.08	154.69	153.14
<u>Labor Income</u>				
Direct	0.63	34.51	62.75	62.12
Indirect	0.21	11.56	21.02	20.81
Induced	0.31	17.12	31.27	30.95
Total	1.15	63.27	115.03	113.88
<u>Employment</u>				
Direct	14.0	767.3	1,395.0	1,381.1
Indirect	7.8	427.0	776.4	768.7
Induced	11.9	653.5	1,188.2	1,176.3
Total	33.6	1,847.8	3,359.6	3,326.0
<u>Output</u>				
Direct	1.80	99.00	180.00	178.20
Indirect	0.54	29.63	53.87	53.33
Induced	0.73	40.38	73.42	72.69
Total	3.07	169.01	307.29	304.21

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.30

**Pollution Control Equipment Production
(Gigawatts)
Advanced Technology Case – ACI
Impacts**

Impact Values	*2000-2004	*2005-2009	*2010-2014	*2015-2020
<u>Total Value Added</u>				
Direct	0.00	56.13	103.23	103.23
Indirect	0.00	25.66	47.19	47.19
Induced	0.00	37.92	69.75	69.75
Total	0.00	119.71	220.17	220.17
<u>Labor Income</u>				
Direct	0.00	48.56	89.31	89.31
Indirect	0.00	16.26	29.91	29.91
Induced	0.00	24.20	44.50	44.50
Total	0.00	89.02	163.73	163.73
<u>Employment</u>				
Direct	0.00	1,079.6	1,985.6	1,985.6
Indirect	0.00	600.9	1,105.1	1,105.1
Induced	0.00	919.5	1,691.2	1,691.2
Total	0.00	2,600.0	4,781.9	4,781.9
<u>Output</u>				
Direct	0.00	139.30	256.20	256.20
Indirect	0.00	41.69	76.67	76.67
Induced	0.00	56.82	104.50	104.50
Total	0.00	237.81	437.37	437.37

*Represents annual values averaged over the time intervals listed.

Numbers are in millions of dollars except for employment. Employment represents actual numbers.

TABLE 5.31

**TOTAL IMPACTS FROM MULTIPLE EMISSIONS REGULATIONS ON THE
OKLAHOMA ECONOMY, 2000 through 2020
(\$Millions, Number Employed)**

REFERENCE CASE

Impact Values	Δ Value Added	Δ Labor Income	Δ Employment	Δ Output
Δ Electricity Generating Capacity	-\$1800.47	-\$1,418.75	-49,867.1	-\$3,576.96
Coal*	-\$8,164.77	-\$6,170.05	-216,869.3	-\$15,555.90
Other**	\$6,364.30	\$4,751.30	167,002.2	\$11,978.94
Δ Electricity Generation	-\$6,482.18	-\$2,074.00	-45,933.6	-\$8,382.05
Coal	-\$17,131.52	-\$5,481.22	-121,396.1	-\$22,152.71
Other	\$10,649.34	\$3,407.22	75,462.5	\$13,770.66
Δ Pollution Control Equipment Manufacturing	\$4,075.65	\$3,030.76	88,517.3	\$8,096.13
NO _x	\$2,301.01	\$1,711.06	49,974.6	\$4,570.92
ACI	\$1,774.64	\$1,319.70	38,542.7	\$3,525.21
TOTALS	-\$4,207.00	-\$461.99	-7,283.4	-\$3,862.88

*Not a construction impact, deals with a reduced demand for coal.

**Includes construction impacts.

TABLE 5.32

**TOTAL IMPACTS FROM MULTIPLE EMISSIONS REGULATIONS ON THE
OKLAHOMA ECONOMY, 2000 through 2020
(\$Millions, Number Employed)**

ADVANCED TECHNOLOGY CASE

Impact Values	Δ Value Added	Δ Labor Income	Δ Employment	Δ Output
Δ Electricity Generating Capacity	-\$26.22	-\$19.65	-688.4	-\$49.29
Coal*	-\$8,274.41	-\$6,177.35	-217,123.7	-\$15,574.18
Other**	\$8,248.19	\$6,157.70	216,435.3	\$15,524.89
Δ Electricity Generation	-\$1,422.74	-\$455.26	-10,081.8	-\$1,839.69
Coal	-\$12,362.39	-\$3,955.31	-87,601.7	-\$15,985.75
Other	\$10,939.65	\$3,500.05	77,519.9	\$14,146.06
Δ Pollution Control Equipment Manufacturing	\$5,145.86	\$3,826.66	111,761.9	\$10,222.23
NO _x	\$2,125.44	\$1,580.53	46,161.0	\$4,222.11
ACI	\$3,020.42	\$2,246.13	65,600.9	\$6,000.12
TOTALS	\$3,696.90	\$3,351.75	100,991.7	\$8,333.25

*Not a construction impact, deals with a reduced demand for coal.

**Includes construction impacts.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

A Summary View

The focus of this study was on multiple emissions regulations under consideration in the U.S. Congress. A set of these regulations were analyzed for national impacts by the EIA, using NEMS, for both "reference" and "advanced technology" cases. The effects of these national impacts on key Oklahoma economic variables were determined by constructing and validating a bridge model that distributed some portion of the national impacts to Oklahoma. The outputs of the bridge model were treated (primarily) as changes in final demand in the context of IMPLAN's input-output model for Oklahoma. The IMPLAN model then determined the total impacts of the proposed multiple emissions regulations on income, output, and employment in the state.

The potential impacts of the proposed regulations on the national economy are primarily negative (lower income, employment, and output). In each case at the national level, the total cumulative resource cost of generating electricity was projected to increase by 8 to 9 percent when the emission limits become law. In both cases, the imposed emission limits increases the anticipated demand for natural gas because of the higher demand by electric power producers that are subject to the emission limits. Because of the projected increase in natural gas demand, natural gas prices are anticipated to increase in both cases.

From a national prospective, the assumed emissions limits are expected to have measurable negative short-term impacts on the economy as a whole, when the limits are completely imposed in 2007. However, in both cases the impact is significantly reduced even by 2010, as the economy adjusts to higher energy prices.

From a state prospective, the results from this study show that electricity prices will increase and the total electricity generated will decrease, especially from coal-fired plants. Therefore, Oklahoma income, output, and employment will decrease. On the other hand, Oklahoma's production of electricity from natural gas and petroleum-fired power plants will increase, the generation of electricity for out of state use will increase, and pollution control equipment manufacturing will increase, therefore having a positive effect on the Oklahoma economy.

Tables 5.31 and 5.32 indicate that the net effect on Oklahoma on an annual basis, ranges from -\$200 million worst case to +\$176 million best case for value added impacts; from -\$22 million worst case to +\$160 million best case for labor income impacts; from -347 worst case to +4,809 best case for employment impacts; and -\$184 million worst case to +\$397 million best case for output impacts.

It should be noted that the MW's of new generating capacity shown in Table 4.4 has probably been under estimated. The effects from new regulations on electricity generated by natural gas is quite likely to be under estimated given Oklahoma's abundance and advantage of producing natural gas. Other

advantages include the availability of Indian land and the tax incentives for companies that produce natural gas from these lands.

Limitations of the Study and Suggestions for Future Research

1. Suggestions of key personnel at Energy Information Administration headquarters in Washington D.C. were used to distribute the impacts on the Southwest Power Pool to Oklahoma. A more detailed study of existing and planned power plants in the region may indicate a different distribution than the one supplied by the Energy Information Administration experts.
2. This study provides an estimate of the costs of future environmental regulations, but ignores the benefits from them. Given that the costs are relatively small, it is possible that an additional study would indicate that the expected benefits would be greater than the expected costs.
3. This study ignores the impact of the proposed regulations on the emissions trading industry in Oklahoma. As these proposed regulations become law, firms such as Cantor Fitzgerald have indicated a willingness to locate offices in Oklahoma. Further study is needed, however, to determine how large this impact is likely to be.

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APPENDIXES

Appendix A.1

ELECTRICITY SUPPLY, DISPOSITION, PRICES & EMISSIONS

Table C8. Electricity Supply, Disposition, Prices, and Emissions
(Billion Kilowatthours, Unless Otherwise Noted)

Supply, Disposition, and Prices	1999	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Generation by Fuel Type									
Electric Generators¹									
Coal	1830	2105	1739	2091	1753	2238	1276	2240	1324
Petroleum	85	42	14	36	13	25	11	20	11
Natural Gas ²	370	582	788	580	780	826	1395	719	1292
Nuclear Power	730	740	740	740	740	720	741	744	744
Pumped Storage	-1	-1	-1	-1	-1	-1	-1	-1	-1
Renewable Sources ³	355	372	455	383	431	396	492	402	515
Total	3369	3839	3735	3809	3718	4204	3914	4125	3885
Nonutility Generation for Own Use	16	17	21	17	21	17	19	17	19
Distributed Generation	0	0	0	0	0	1	0	1	0
Cogenerators⁴									
Coal	47	53	52	53	52	51	48	51	48
Petroleum	9	10	10	10	10	10	10	10	10
Natural Gas	206	236	249	237	251	259	320	260	316
Other Gaseous Fuels ⁵	4	6	6	6	6	7	7	7	7
Renewable Sources ⁶	31	34	34	36	35	39	39	43	43
Other ⁷	5	5	5	5	5	5	5	5	5
Total	303	344	357	347	360	372	426	376	427
Other End-Use Generators⁷									
Sales to Utilities	151	172	171	172	172	179	182	180	182
Generation for Own Use	156	177	190	179	193	197	249	202	250
Net Imports ⁸	33	57	57	57	57	35	47	35	47
Electricity Sales by Sector									
Residential	1145	1337	1300	1330	1299	1438	1344	1421	1343
Commercial	1073	1291	1254	1283	1252	1442	1357	1421	1355
Industrial	1058	1137	1108	1122	1094	1219	1137	1180	1110
Transportation	17	26	26	22	22	34	34	27	27
Total	3294	3790	3688	3757	3667	4133	3872	4049	3835
End-Use Prices (1999 cents per kwh)⁹									
Residential	8.1	7.6	8.4	7.5	8.2	7.6	9.5	7.4	8.6
Commercial	7.4	6.9	8.0	6.8	7.7	6.4	8.5	6.1	7.7
Industrial	4.5	4.4	5.1	4.3	4.9	4.1	5.7	3.9	5.2
Transportation	5.3	5.0	5.3	5.0	5.3	4.7	5.7	4.7	5.4
All Sectors Average	6.7	6.4	7.3	6.3	7.0	6.1	8.0	5.9	7.4
Prices by Service Category⁹									
(1999 cents per kilowatthour)									
Generation	4.1	3.8	4.6	3.7	4.4	3.4	5.2	3.2	4.5
Transmission	0.6	0.6	0.7	0.6	0.7	0.7	0.8	0.7	0.8
Distribution	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.0	2.1
Emissions (million short tons)									
Sulfur Dioxide	13.49	10.39	6.34	10.39	6.34	9.70	2.99	9.70	2.99
Nitrogen Oxide	5.43	4.30	2.70	4.26	2.67	4.34	1.64	4.18	1.76

¹Includes grid-connected generation at all utilities and nonutilities except for cogenerators. Includes small power producers and exempt wholesale generators.

²Includes electricity generation by fuel cells.

³Includes conventional hydroelectric, geothermal, wood, wood waste, municipal solid waste, landfill gas, other biomass, solar, and wind power.

⁴Cogenerators produce electricity and other useful thermal energy. Includes sales to utilities and generation for own use.

⁵Other gaseous fuels include refinery and still gas.

⁶Other includes hydrogen, sulfur, batteries, chemicals, fish oil, and spent sulfate liquor.

⁷Includes small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
⁸In 1999 approximately 70 percent of the U.S. electricity imports were provided by renewable sources (hydroelectricity); EIA does not project future proportions for the fuel source of imported electricity.

⁹Prices represent average revenue per kilowatthour.

Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model results and may differ slightly from official EIA data reports.

Sources: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEI.D081801A, SCENBBS.D080301A, SCENBEM.D081701A.

Appendix A.1 (continued)

ELECTRICITY SUPPLY, DISPOSITION, PRICES & EMISSIONS

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
2279	1148	2260	1230	2302	1041	2248	1148
24	12	18	10	23	11	18	10
1188	1759	885	1584	1488	2072	1331	1911
653	719	735	741	810	689	672	720
-1	-1	-1	-1	-1	-1	-1	-1
400	500	408	519	399	519	409	524
4524	4135	4405	4084	4821	4311	4874	4308
17	16	16	19	16	16	16	19
3	1	2	0	5	1	4	1
52	44	51	45	52	44	51	42
10	10	10	10	10	10	10	10
287	420	288	402	317	548	311	484
8	8	7	7	8	8	7	8
44	44	51	51	48	48	59	59
5	5	5	5	6	8	5	5
406	532	411	520	440	664	444	608
5	5	5	5	5	5	5	5
193	211	194	210	208	253	209	238
218	326	222	315	237	415	239	374
22	34	22	34	23	35	23	35
1545	1442	1518	1432	1668	1543	1636	1554
1567	1459	1535	1452	1653	1515	1618	1526
1298	1166	1243	1129	1394	1213	1320	1176
43	43	32	32	49	48	36	36
4453	4109	4328	4048	4783	4320	4810	4284
7.6	9.4	7.2	8.8	7.8	9.5	7.0	8.1
6.4	8.5	5.9	7.4	6.4	8.8	5.6	6.9
4.1	5.7	3.7	5.0	4.1	5.9	3.5	4.8
4.8	5.5	4.5	5.3	4.5	5.5	4.3	4.9
6.1	8.0	5.7	7.1	6.1	8.1	5.5	6.7
3.4	5.2	3.0	4.4	3.5	5.5	2.9	4.0
0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
2.0	2.1	2.0	2.1	2.0	2.0	2.0	2.0
8.95	2.64	8.95	2.64	8.95	2.24	8.95	2.24
4.44	1.53	4.26	1.68	4.48	1.42	4.25	1.58

Appendix A.1 (continued)

ELECTRICITY GENERATING CAPABILITY

**Table C9. Electricity Generating Capability
(Gigawatts)**

Net Summer Capability ¹	1990	Projections							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Electric Generators²									
Capability									
Coal Steam	305.1	303.9	302.8	303.8	302.8	317.8	252.8	325.1	255.1
Other Fossil Steam ³	137.4	124.9	111.6	124.8	112.2	117.4	99.1	115.6	98.8
Combined Cycle	21.0	52.4	107.5	51.6	106.5	107.3	193.2	85.7	171.9
Combustion Turbine/Diesel	88.8	126.4	124.5	126.0	128.4	149.8	137.9	147.7	139.3
Nuclear Power	97.4	97.5	97.5	97.5	97.5	93.7	96.9	97.5	97.5
Pumped Storage	19.3	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Renewable Sources ⁴	88.8	94.7	99.2	96.0	99.3	97.9	105.0	96.4	113.5
Distributed Generation ⁵	0.0	0.8	0.2	0.7	0.2	2.5	0.9	2.1	0.6
Total	755.9	820.0	862.9	819.8	866.4	906.0	905.4	892.8	896.2
Cumulative Planned Additions⁶									
Coal Steam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Fossil Steam ³	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Combined Cycle	0.0	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
Combustion Turbine/Diesel	0.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Nuclear Power	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Renewable Sources ⁴	0.0	5.1	5.1	5.1	5.1	6.7	6.7	6.7	6.7
Distributed Generation ⁵	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	32.0	32.0	32.0	32.0	33.7	33.7	33.7	33.7
Cumulative Unplanned Additions⁶									
Coal Steam	0.0	1.1	0.0	1.0	0.0	18.2	0.0	25.8	0.0
Other Fossil Steam ³	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Combined Cycle	0.0	18.6	73.8	17.8	72.7	73.6	159.8	52.1	138.2
Combustion Turbine/Diesel	0.0	30.9	18.6	30.4	22.4	55.4	32.8	53.9	34.0
Nuclear Power	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Sources ⁴	0.0	0.4	4.9	1.7	5.0	1.9	8.0	3.4	17.8
Distributed Generation ⁵	0.0	0.8	0.2	0.7	0.2	2.5	0.9	2.1	0.6
Total	0.0	51.7	97.5	51.6	100.3	151.5	202.3	137.0	190.4
Cumulative Total Additions	0.0	83.7	129.5	83.6	132.3	185.2	236.0	170.7	224.1
Cumulative Retirements⁷									
Coal Steam	0.0	2.3	2.3	2.3	2.3	5.5	52.4	5.8	50.1
Other Fossil Steam ³	0.0	12.7	26.0	12.6	25.5	20.2	38.5	22.0	38.8
Combined Cycle	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.1
Combustion Turbine/Diesel	0.0	5.5	5.1	5.5	5.0	6.6	5.9	7.2	5.9
Nuclear Power	0.0	0.0	0.0	0.0	0.0	3.7	0.8	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Renewable Sources ⁴	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	0.0	20.6	33.5	20.8	33.0	36.4	97.7	35.2	95.1

Appendix A.1 (continued)

ELECTRICITY GENERATING CAPABILITY

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
317.9	232.1	325.1	248.8	317.3	224.9	323.9	242.5
118.4	91.1	114.7	98.4	114.9	89.7	111.8	92.8
152.8	238.7	108.8	203.8	199.0	287.3	159.4	252.3
174.4	144.8	174.8	143.5	197.4	146.3	197.1	148.8
81.5	92.9	83.8	96.8	76.3	85.4	87.0	94.8
19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
98.9	107.2	100.4	115.2	99.4	112.5	101.3	118.8
5.8	1.9	4.8	0.9	11.0	3.0	9.1	1.8
967.2	926.3	941.8	923.0	1035.1	989.0	1009.4	971.3
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
7.7	7.7	7.7	7.7	8.1	8.1	8.1	8.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34.8	34.8	34.8	34.8	35.3	35.3	35.3	35.3
18.6	0.0	26.1	0.0	19.5	0.0	26.1	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
119.0	203.1	75.2	171.2	165.4	253.7	125.8	220.0
80.1	39.8	80.9	38.4	103.1	42.1	103.4	44.4
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.9	10.2	3.4	18.2	1.9	15.0	3.8	21.3
5.8	1.9	4.8	0.9	11.0	3.0	9.1	1.8
229.5	254.8	190.3	228.7	309.8	313.8	288.3	287.4
280.4	289.7	225.1	283.5	336.1	349.1	303.8	322.7
6.0	73.0	6.1	58.3	7.3	80.2	7.4	62.8
21.2	48.5	23.0	41.2	22.7	47.9	25.6	44.9
0.2	0.2	0.2	1.4	0.2	0.2	0.2	1.4
8.7	8.0	7.4	8.0	6.7	8.8	7.4	8.9
16.0	4.8	3.8	0.7	21.2	12.1	10.4	2.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
50.3	130.5	40.4	107.8	58.1	147.3	81.3	118.8

Appendix A.1 (continued)

ELECTRICITY GENERATING CAPABILITY

Table C9. Electricity Generating Capability (Continued)
(Gigawatts)

Net Summer Capability ^d	1999	Projections ^e							
		2005				2010			
		Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
Cogenerators ^d									
Capability									
Coal	8.4	8.9	8.9	8.9	8.9	8.8	7.5	8.5	7.5
Petroleum	2.7	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Natural Gas	34.6	39.7	41.8	38.9	42.1	43.1	51.6	43.4	51.4
Other Gaseous Fuels	0.2	0.8	0.8	0.8	0.8	0.9	0.9	0.8	0.8
Renewable Sources ^e	5.4	5.9	5.9	6.1	6.1	6.8	8.8	7.5	7.5
Other	1.1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total	52.4	58.1	61.1	58.5	61.7	63.1	70.6	63.9	71.0
Cumulative Additions ^d	0.0	6.7	8.7	7.1	9.3	10.7	18.1	11.5	18.6
Other End-Use Generators ^d									
Renewable Sources ¹⁰	1.0	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.3
Cumulative Additions	0.0	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.3

¹Net summer capability is the steady hourly output that generating equipment is expected to supply to system load (exclusive of auxiliary power), as demonstrated by tests during summer peak demand.

²Includes grid-connected utilities and nonutilities except for cogenerators. Includes small power producers and exempt wholesale generators.

³Includes oil-, gas-, and dual-fired capability.

⁴Includes conventional hydroelectric, geothermal, wood, wood waste, municipal solid waste, landfill gas, other biomass, solar and wind power.

⁵Primarily peak-load capacity fueled by natural gas.

⁶Cumulative additions after December 31, 1999.

⁷Cumulative total retirements after December 31, 1999.

⁸Nameplate capacity is reported for nonutilities on Form EIA-900B, "Annual Electric Generator Report - Nonutility." Nameplate capacity is designated by the manufacturer. The nameplate capacity has been converted to the net summer capability based on historic relationships.

⁹Includes small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid. Excludes off-grid photovoltaics and other generators not connected to the distribution or transmission systems.

¹⁰See Table C17 for more detail.

Note: Totals may not equal sum of components due to independent rounding. Data for 1999 are model estimates and may differ slightly from official EIA data reports. Net summer capability has been estimated for nonutility generators to be consistent with capability for electric utility generators.

Source: Energy Information Administration, AEO2001 National Energy Modeling System runs SCENABS.D080301A, SCENAEM.D081801A, SCENBBS.D080301A, SCENBEM.D081701A.

Appendix A.1 (continued)

ELECTRICITY GENERATING CAPABILITY

Projections							
2015				2020			
Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits	Reference	Reference with Emissions Limits	Advanced Technology	Advanced Technology with Emissions Limits
8.6	7.3	8.5	7.5	8.6	7.3	8.4	7.4
2.9	2.9	2.9	2.9	2.9	3.0	2.9	2.9
46.9	65.4	46.9	62.9	51.2	63.2	50.5	74.4
1.0	1.0	0.9	0.9	1.1	1.1	0.9	1.0
7.6	7.6	8.9	8.9	8.3	8.3	10.2	10.2
0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
67.9	85.1	68.9	83.9	73.0	103.8	73.8	98.8
15.5	32.7	16.4	31.5	20.5	51.4	21.4	44.4
1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4

Appendix A.2

Reference Case – Without Emission Limits

Table A2. Electric Power Projections for 2041 Region
10 - Southwest Power Pool

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Electricity Generating Cap... (gigawatts)													
Coal Steam.....	20.95	20.95	20.95	20.95	20.95	20.95	20.95	20.95	20.92	20.99	21.33	21.33	21.33
Other Fossil Steam.....	14.28	14.17	14.10	14.00	13.49	13.21	11.91	11.30	10.99	10.96	10.96	10.96	10.96
Combined Cycle.....	1.51	1.71	2.47	2.63	2.63	2.63	2.63	2.63	2.82	3.05	3.51	3.93	4.13
Combustion Turbine/Diesel.....	4.51	4.71	4.71	4.71	4.56	4.69	6.23	7.35	8.04	8.09	8.14	8.14	8.32
Nuclear Power.....	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Pumped Storage/Other.....	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	2.55	2.55	2.55	2.55	2.56	2.56	2.56	2.56	2.57	2.57	2.57	2.58	2.58
Total Capability.....	45.47	45.76	46.61	46.51	45.84	45.70	45.94	46.45	47.00	47.33	48.19	48.61	49.00
Cumulative Planned Additions ..													
Coal Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Fossil Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined Cycle.....	0.00	0.19	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Combustion Turbine/Diesel.....	0.00	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Nuclear Power.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pumped Storage/Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Planned Additions.....	0.00	0.43	1.35	1.35	1.36	1.36	1.36	1.36	1.37	1.37	1.37	1.37	1.38
Cumulative Unplanned Addit. ..													
Coal Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.05	1.39	1.39	1.39
Other Fossil Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined Cycle.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.52	0.96	1.40	1.60
Combustion Turbine/Diesel.....	0.00	0.00	0.00	0.00	0.00	0.14	1.74	2.97	3.67	3.71	3.76	3.76	3.94
Nuclear Power.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pumped Storage/Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Unplanned Additions.....	0.00	0.00	0.00	0.00	0.00	0.14	1.74	2.97	4.35	5.29	6.14	6.56	6.94
Cumulative Total Additions.....	0.00	0.43	1.35	1.35	1.36	1.50	3.10	4.33	5.72	6.66	7.51	7.94	8.32
Cumulative Retirements.....													
	0.00	0.10	0.18	0.28	0.94	1.29	2.72	3.45	4.29	4.90	4.90	4.90	4.90
Cogenerators ..													
Capability													
Coal.....	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Petroleum.....	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Natural Gas.....	0.70	0.70	0.71	0.72	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.86
Other Gaseous Fuels.....	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Renewable Sources.....	0.35	0.35	0.35	0.35	0.37	0.38	0.39	0.41	0.42	0.44	0.45	0.46	0.47
Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total.....	1.56	1.56	1.58	1.58	1.61	1.63	1.66	1.69	1.73	1.76	1.78	1.81	1.84
Electricity Demand (billion kilowatt-hours)													
Residential.....	56.25	58.25	59.98	61.60	63.06	64.44	65.77	66.55	67.28	68.42	69.80	71.03	72.08
Commercial.....	53.67	55.65	57.98	59.80	61.67	63.21	64.76	66.35	67.84	69.40	71.17	72.75	74.33
Commercial/Other.....	50.51	51.57	51.93	52.29	53.09	53.81	54.81	55.86	56.50	57.42	57.83	58.52	58.83
Industrial.....	0.65	0.67	0.69	0.71	0.80	0.89	0.97	1.05	1.11	1.18	1.24	1.31	1.37
Transportation.....	161.10	166.15	170.49	176.40	178.64	182.35	186.30	189.80	192.73	196.41	200.05	204.01	206.61
Total Sales.....													
Net Energy for Load (bil.kwh) ..													
Gross International Imports.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross International Exports.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Interregional Elec. Imp. Exp.	13.65	21.16	22.65	22.03	22.37	23.13	23.35	24.45	25.19	25.48	24.30	23.75	23.36
Gross Interregional Elec. Exp. Purchases from cogenerators ..	24.82	22.59	20.46	20.59	20.26	20.82	19.82	18.18	16.81	15.12	14.56	12.97	11.54
Util. Generation for Customers	3.66	3.70	3.72	3.76	3.82	3.89	3.96	4.04	4.11	4.19	4.27	4.36	4.45
Total Net Energy for Load.....	181.78	177.73	178.67	183.48	187.24	190.87	193.75	194.80	195.29	197.49	201.79	204.82	206.31
Generation by Fuel Type (billion kilowatt-hours)													
Coal.....	130.78	135.55	139.19	142.91	146.66	150.68	154.40	154.31	154.14	154.68	157.16	157.27	157.28
Petroleum.....	0.67	0.51	2.12	1.16	0.97	0.92	0.75	0.72	0.70	0.66	0.61	0.62	0.57
Natural Gas.....	35.15	27.09	22.57	24.50	24.56	24.36	23.68	24.84	25.52	27.19	28.06	31.97	33.48
Nuclear.....	9.44	9.81	9.81	9.72	9.62	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53
Pumped Storage/Other.....	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
Renewable Sources.....	8.40	4.83	5.04	5.24	5.47	5.44	5.44	5.44	5.45	5.47	5.48	5.48	5.49
Total Generation.....	181.78	177.73	178.68	183.48	187.24	190.87	193.75	194.80	195.29	197.49	201.79	204.82	206.31
Sales to Customers.....	181.78	177.73	178.67	183.48	187.24	190.87	193.75	194.80	195.29	197.49	201.79	204.82	206.31
Generation for Own Use.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cogenerators													
Coal.....	3.32	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36
Petroleum.....	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Natural Gas.....	2.83	2.85	2.97	2.99	3.07	3.18	3.28	3.40	3.50	3.61	3.72	3.82	3.94
Other Gaseous Fuels.....	0.05	0.05	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08
Renewable Sources.....	2.24	2.24	2.25	2.25	2.33	2.40	2.49	2.58	2.66	2.75	2.83	2.91	2.98
Other.....	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total.....	9.64	9.70	9.86	9.89	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94
Sales to Utilities.....	3.66	3.70	3.72	3.74	3.82	3.89	3.96	4.04	4.11	4.19	4.27	4.36	4.45
Generation for Own Use.....	4.98	5.00	5.15	5.13	5.22	5.34	5.46	5.59	5.71	5.82	5.93	6.03	6.12
End-Use Prices (1999 cents per kilowatt-hour)													
Residential.....	5.8	5.6	5.5	5.4	5.4	5.4	5.4	6.2	6.4	6.6	6.7	6.7	6.8
Commercial.....	6.3	6.1	6.0	6.5	6.3	6.2	6.2	6.2	6.3	6.4	6.3	6.3	6.3
Industrial.....	3.3	3.2	3.1	3.5	3.5	3.5	3.5	3.6	3.7	3.8	3.8	3.8	3.9
Transportation.....	4.5	4.5	4.5	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
All Sectors Average.....	5.2	5.0	4.9	5.2	5.1	5.1	5.1	5.4	5.6	5.7	5.7	5.7	5.8
Prices by Service Category (1999 cents/kwh)													
Generation.....	2.6	2.4	2.4	2.8	2.7	2.7	2.8	3.0	3.1	3.3	3.3	3.3	3.4
Transmission.....	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
Distribution.....	2.0	2.0	2.0	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Fuel Consumption (quad. Btu) ..													
Coal.....	1.38	1.43	1.47	1.51	1.55	1.60	1.64	1.64	1.63	1.63	1.65	1.65	1.65
Natural Gas.....	0.36	0.27	0.22	0.24	0.24	0.24	0.23	0.24	0.25	0.26	0.27	0.29	0.30
Oil.....	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total.....	1.75	1.71	1.71	1.76	1.80	1.84	1.88	1.89	1.88	1.89	1.92	1.95	1.96
Emissions(million short tons) ..													
Total Carbon.....	45.91	45.70	46.28	47.44	48.51	49.58	50.69	50.84	50.68	50.81	51.52	51.84	52.13
Carbon Dioxide.....	189.35	187.57	189.71	173.94	177.87	182.16	185.87	184.42	185.84	186.29	188.90	190.05	191.16
Sulfur Dioxide.....	0.41	0.40	0.42	0.44	0.45	0.47	0.48	0.48	0.47	0.45	0.46	0.46	0.45
Nitrogen Oxide.....	0.32	0.30	0.30	0.31	0.31	0.32	0.33	0.33	0.32	0.32	0.32	0.32	0.32

Appendix A.2

Reference Case – Without Emission Limits

2012	2013	2014	2015	2016	2017	2018	2019	2020
21.33	21.33	21.33	21.33	21.33	21.33	21.33	21.33	21.33
10.96	10.96	10.96	10.96	10.96	10.96	10.96	10.96	10.96
4.41	4.94	5.56	5.42	6.17	6.52	6.90	7.24	7.58
8.52	8.88	8.88	9.72	9.87	10.41	10.66	11.06	11.22
1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.59	2.59	2.40	2.40	2.41	2.61	2.62	2.62	2.63
49.47	50.38	51.00	51.93	52.65	53.35	54.20	54.96	55.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07
1.39	1.39	1.39	1.40	1.40	1.41	1.41	1.42	1.42
1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.09	2.41	3.03	3.99	3.64	3.99	4.37	4.71	5.05
4.14	4.50	4.50	5.35	5.50	6.03	6.29	6.68	6.84
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.42	8.31	8.93	9.85	10.57	11.46	12.11	12.87	13.37
8.80	9.70	10.33	11.25	11.97	12.87	13.53	14.29	14.80
4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90
0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.87	0.89	0.91	0.93	0.95	0.97	0.99	1.01	1.03
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.49	0.50	0.51	0.52	0.53	0.54	0.55	0.56	0.57
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.87	1.90	1.93	1.96	1.99	2.02	2.05	2.08	2.11
73.27	74.36	75.52	76.77	77.92	79.19	80.48	81.84	83.15
75.85	77.18	78.50	79.68	80.49	81.69	82.61	83.48	84.13
60.06	60.85	61.68	62.47	63.20	64.16	64.83	65.82	66.83
1.44	1.50	1.56	1.59	1.58	1.57	1.55	1.53	1.50
210.62	213.89	217.25	220.51	223.49	226.61	229.47	232.46	235.41
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.66	22.00	19.97	19.64	18.40	17.17	16.97	16.84	16.59
10.29	9.33	7.81	6.48	5.48	4.13	3.14	2.38	1.68
4.34	4.45	4.75	4.86	4.97	5.08	5.19	5.30	5.43
208.81	212.65	216.60	218.99	222.09	225.18	227.34	230.01	232.59
226.72	229.97	233.51	236.81	239.99	243.30	246.36	249.78	252.93
157.42	157.58	157.64	157.69	157.72	157.74	157.74	157.75	157.76
0.61	0.57	0.58	0.61	0.60	0.62	0.60	0.58	0.60
35.79	38.51	43.38	45.66	48.73	51.76	53.92	56.59	59.13
9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53
-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
5.50	5.51	5.52	5.53	5.54	5.55	5.56	5.57	5.58
208.81	212.65	216.60	218.99	222.10	225.18	227.34	230.01	232.59
208.81	212.65	216.60	218.99	222.09	225.18	227.34	230.01	232.59
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
4.05	4.18	4.30	4.44	4.58	4.72	4.85	4.98	5.11
0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
3.05	3.13	3.20	3.27	3.34	3.40	3.46	3.52	3.58
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
10.76	10.97	11.16	11.38	11.59	11.79	11.99	12.17	12.37
4.34	4.45	4.75	4.86	4.97	5.08	5.19	5.30	5.43
6.22	6.32	6.41	6.52	6.62	6.71	6.79	6.87	6.94
6.8	6.7	6.8	6.7	6.8	6.8	6.8	6.7	6.8
6.3	6.2	6.3	6.2	6.3	6.2	6.2	6.2	6.2
3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
4.3	4.3	4.2	4.2	4.2	4.2	4.2	4.1	4.1
5.8	5.7	5.8	5.7	5.8	5.7	5.7	5.7	5.7
3.4	3.4	3.4	3.4	3.5	3.5	3.5	3.5	3.5
0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6
1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65
0.32	0.34	0.37	0.39	0.41	0.43	0.44	0.45	0.47
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1.98	2.00	2.03	2.05	2.07	2.09	2.10	2.11	2.13
52.51	52.94	53.34	53.67	53.93	54.28	54.43	54.69	54.97
192.54	194.11	195.58	196.80	197.75	199.03	199.57	200.52	201.57
0.45	0.45	0.45	0.45	0.46	0.46	0.46	0.46	0.45
0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32

Appendix A.2

Reference Case - With Emission Limits

Table 62. Electric Power Projections for ERM Region
10 - Southwest Power Pool

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Electricity Generating Cap... (gigawatts)													
Coal Steam.....	20.95	20.95	20.95	20.95	20.95	20.95	20.95	19.87	19.29	18.34	18.29	18.14	18.11
Other Fossil Steam.....	14.28	14.17	14.10	14.00	13.44	12.84	11.54	10.92	10.61	10.39	10.39	10.39	10.39
Combined Cycle.....	1.51	1.71	2.63	2.63	2.63	4.60	6.89	6.89	7.08	8.86	9.07	9.35	9.55
Combustion Turbine/Diesel.....	6.07	6.31	6.31	6.27	6.11	6.11	6.05	5.94	5.94	5.94	5.94	5.94	5.94
Nuclear Power.....	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Pumped Storage/Other.....	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	2.55	2.55	2.55	2.55	2.56	2.56	2.57	2.57	2.57	2.57	2.58	2.58	2.59
Total Capability.....	47.03	47.16	48.20	48.07	47.35	48.72	49.66	47.86	47.77	47.97	48.13	48.46	48.44
Cumulative Planned Additions ..													
Coal Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Fossil Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined Cycle.....	0.00	0.19	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Combustion Turbine/Diesel.....	0.00	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Nuclear Power.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pumped Storage/Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.03
Total Planned Additions.....	0.00	0.43	1.35	1.35	1.36	1.36	1.36	1.36	1.37	1.37	1.37	1.37	1.38
Cumulative Unplanned Addit. ..													
Coal Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Fossil Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined Cycle.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combustion Turbine/Diesel.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nuclear Power.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pumped Storage/Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Unplanned Additions.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cumulative Total Additions...	0.00	0.43	1.35	1.35	1.36	1.36	1.36	1.36	1.37	1.37	1.37	1.37	1.38
Cumulative Retirements.....													
Coal.....	0.00	0.10	0.18	0.32	1.03	1.70	3.13	4.94	5.83	6.90	6.96	7.11	7.13
Cogenerators ..													
Capability													
Coal.....	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Petroleum.....	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Natural Gas.....	0.70	0.70	0.72	0.72	0.75	0.78	0.81	0.85	0.90	0.94	0.99	1.04	1.10
Other Gaseous Fuels.....	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Renewable Sources.....	0.35	0.35	0.35	0.35	0.36	0.38	0.39	0.41	0.42	0.44	0.45	0.46	0.47
Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total.....	1.56	1.56	1.58	1.58	1.62	1.67	1.71	1.76	1.83	1.89	1.95	2.01	2.08
Electricity Demand (billion kilowatthours)													
Residential.....	56.25	58.25	59.98	60.57	61.41	62.96	63.90	63.15	62.12	63.53	64.81	65.41	66.24
Commercial/Other.....	53.67	55.45	57.98	57.92	58.86	60.83	62.01	62.66	62.44	64.22	65.83	66.71	67.93
Industrial.....	50.51	51.57	51.86	51.82	51.87	52.49	53.18	53.48	53.56	54.10	54.10	54.27	53.79
Transportation.....	0.66	0.67	0.69	0.71	0.80	0.89	0.97	1.05	1.11	1.18	1.24	1.31	1.37
Total Sales.....	161.10	166.15	170.52	171.02	172.94	177.16	180.06	180.53	179.23	183.03	185.99	187.70	189.33
Net Energy for Load (bil.kwh) ..													
Gross International Imports.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross International Exports.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Interregional Elec. Imp.	13.88	21.25	22.69	19.98	17.00	18.12	15.86	16.70	19.55	20.64	22.37	18.44	17.66
Gross Interregional Elec. Exp.	24.16	21.17	20.05	21.72	20.49	20.32	18.46	13.66	12.50	13.43	13.80	12.50	10.32
Purchases from cogenerators ..	3.67	3.70	3.72	3.69	3.75	3.81	3.88	3.98	4.21	4.33	4.44	4.57	4.70
Util. Generation for Customers ..	181.10	176.26	178.27	183.91	186.56	189.75	193.15	185.96	182.29	185.96	187.70	191.89	192.08
Total Net Energy for Load...	174.49	180.03	184.63	184.87	186.82	191.35	194.43	194.98	193.56	197.50	200.70	202.39	204.12
Generation by Fuel Type (billion kilowatthours)													
Coal.....	130.80	135.51	139.15	138.97	140.66	140.84	132.44	120.38	109.29	106.51	108.29	107.07	105.25
Petroleum.....	0.63	0.48	2.12	0.87	0.61	0.36	0.19	0.27	0.37	0.28	0.27	0.29	0.28
Natural Gas.....	34.62	25.69	22.38	25.38	25.16	27.73	31.71	44.10	51.92	58.58	58.45	63.93	66.01
Nuclear.....	9.44	9.81	9.81	9.72	9.62	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53
Pumped Storage/Other.....	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
Renewable Sources.....	5.66	4.83	4.85	9.02	10.56	11.34	12.33	11.72	11.23	11.11	11.20	11.11	11.06
Total Generation.....	181.10	176.26	178.27	183.91	186.56	189.75	193.15	185.96	182.29	185.96	187.70	191.89	192.08
Sales to Customers.....	181.10	176.26	178.27	183.91	186.56	189.75	193.15	185.96	182.29	185.96	187.70	191.89	192.08
Generation for Own Use.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cogenerators													
Coal.....	3.33	3.36	3.36	3.29	3.27	3.26	3.24	3.24	3.36	3.36	3.36	3.36	3.36
Petroleum.....	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Natural Gas.....	2.83	2.85	2.98	3.00	3.21	3.40	3.61	3.87	4.20	4.51	4.82	5.18	5.58
Other Gaseous Fuels.....	0.05	0.05	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08
Renewable Sources.....	2.24	2.24	2.25	2.25	2.31	2.39	2.48	2.56	2.64	2.73	2.81	2.89	2.96
Other.....	8.65	8.70	8.87	8.82	9.07	9.34	9.61	9.96	10.50	10.90	11.29	11.73	12.19
Total.....	3.67	3.70	3.72	3.69	3.75	3.81	3.88	3.98	4.21	4.33	4.44	4.57	4.70
Sales to Utilities.....	4.98	5.01	5.15	5.13	5.32	5.53	5.73	5.98	6.29	6.57	6.85	7.16	7.49
Generation for Own Use.....													
End-Use Prices (1999 cents per kilowatthour)													
Residential.....	5.8	5.6	5.5	5.5	5.6	5.5	5.5	8.4	9.1	8.9	8.8	8.9	9.0
Commercial.....	6.3	6.1	6.0	6.3	6.7	6.0	8.1	8.7	9.6	9.3	9.0	9.1	9.0
Industrial.....	3.3	3.2	3.2	4.5	4.8	4.5	4.6	5.0	5.7	5.6	5.5	5.7	5.8
Transportation.....	4.5	4.6	4.6	4.7	4.8	4.8	4.9	4.9	5.3	5.3	5.3	5.4	5.5
All Sectors Average.....	5.2	5.1	5.0	6.1	6.4	6.0	6.1	7.5	8.2	8.0	7.9	8.0	8.1
Prices by Service Category (1999 cents/kwh)													
Generation.....	2.6	2.5	2.4	3.6	3.9	3.6	3.7	5.0	5.7	5.5	5.4	5.5	5.6
Transmission.....	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7
Distribution.....	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.8	1.8
Fuel Consumption (quad. Btu) ..													
Coal.....	1.38	1.43	1.47	1.47	1.49	1.49	1.40	1.27	1.15	1.12	1.14	1.12	1.11
Natural Gas.....	0.36	0.26	0.22	0.24	0.24	0.22	0.28	0.33	0.38	0.42	0.42	0.46	0.48
Petroleum.....	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil.....	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total.....	1.74	1.69	1.71	1.72	1.73	1.72	1.68	1.60	1.53	1.54	1.56	1.58	1.58
Emissions(million short tons) ..													
Total Carbon.....	45.79	45.43	45.99	45.89	46.08	45.85	44.22	41.27	38.79	38.37	38.98	39.30	39.06
Sulfur Dioxide.....	167.90	166.58	168.62	168.27	168.97	168.13	162.15	151.34	142.23	140.70	142.91	144.10	143.20
Nitrogen Oxide.....	0.41	0.40	0.43	0.44	0.46	0.46	0.41	0.36	0.35	0.35	0.35	0.32	0.31
Mercury.....	0.32	0.29	0.30	0.30	0.30	0.29	0.27	0.24	0.16	0.16	0.16	0.16	0.16

Appendix A.2

Reference Case – With Emission Limits

2012	2013	2014	2015	2016	2017	2018	2019	2020
17.77	16.77	16.77	16.70	16.36	16.36	16.36	16.36	16.36
10.59	10.59	10.59	10.59	10.59	10.59	10.59	10.59	10.59
10.64	11.37	11.53	12.01	12.39	12.93	13.05	13.61	14.06
5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94
1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.59	2.77	2.86	2.93	2.99	3.08	3.17	3.22	3.28
49.20	49.10	49.36	49.83	49.92	50.56	50.76	51.37	51.89
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07
1.38	1.39	1.39	1.40	1.40	1.41	1.41	1.42	1.42
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.11	8.84	9.00	9.48	9.86	10.40	10.51	11.08	11.53
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.18	0.27	0.33	0.38	0.47	0.56	0.60	0.65
8.12	9.02	9.27	9.91	10.24	10.87	11.07	11.57	12.19
9.50	10.41	10.67	11.21	11.65	12.28	12.49	13.09	13.61
7.47	8.47	8.47	8.55	8.89	8.89	8.89	8.89	8.89
0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1.16	1.22	1.29	1.36	1.44	1.52	1.60	1.69	1.78
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.48	0.50	0.51	0.52	0.53	0.54	0.55	0.55	0.56
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.15	2.23	2.30	2.39	2.48	2.57	2.66	2.75	2.85
67.54	68.70	69.58	70.67	71.75	72.79	73.91	74.87	75.81
69.35	70.55	71.44	72.27	73.00	73.59	74.14	74.44	74.64
54.28	54.56	54.79	55.11	55.52	55.87	56.18	56.60	57.03
1.44	1.50	1.56	1.59	1.58	1.57	1.55	1.53	1.50
192.60	195.31	197.36	199.63	201.85	203.81	205.78	207.45	208.98
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.39	14.51	13.21	12.16	12.40	11.71	11.08	10.98	10.47
9.33	7.94	6.73	5.66	4.85	3.89	2.67	2.73	2.41
4.85	5.01	5.17	5.35	5.53	5.72	5.92	6.13	6.35
196.52	198.56	200.54	202.60	203.76	205.39	206.70	208.44	210.07
207.42	210.14	212.19	214.44	216.84	218.94	221.04	222.82	224.48
101.95	97.44	96.47	94.96	93.76	90.64	90.95	90.24	90.38
0.28	0.30	0.31	0.29	0.28	0.29	0.28	0.26	0.21
73.96	79.49	81.93	85.18	87.23	91.53	91.93	94.18	95.31
9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53
-0.05	-0.06	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
10.86	11.83	12.35	12.68	13.01	13.45	14.05	14.28	14.68
194.52	198.56	200.54	202.60	203.76	205.39	206.70	208.44	210.07
196.52	198.56	200.54	202.60	203.76	205.39	206.70	208.44	210.07
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.36	3.36	3.36	3.36	3.36	3.36	3.35	3.35	3.35
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10
5.99	6.40	6.85	7.35	7.87	8.42	8.97	9.54	10.14
0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
3.03	3.11	3.17	3.25	3.32	3.38	3.44	3.50	3.56
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
12.68	13.17	13.69	14.27	14.86	15.47	16.08	16.72	17.38
4.85	5.01	5.17	5.35	5.53	5.72	5.92	6.13	6.35
7.82	8.17	8.52	8.92	9.33	9.75	10.16	10.59	11.03
8.8	8.8	8.9	8.9	8.9	9.0	9.1	9.1	9.2
8.8	8.7	8.9	8.8	8.8	8.8	8.9	8.9	9.0
5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.8	5.9
5.3	5.2	5.3	5.2	5.2	5.2	5.2	5.2	5.2
7.9	7.8	8.0	8.0	8.0	8.0	8.0	8.1	8.2
5.4	5.4	5.5	5.6	5.6	5.7	5.7	5.8	5.9
0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7
1.07	1.02	1.01	1.00	0.98	0.95	0.95	0.94	0.95
0.53	0.56	0.58	0.60	0.61	0.64	0.64	0.65	0.65
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.50	1.59	1.59	1.60	1.60	1.59	1.60	1.60	1.60
38.86	38.07	38.06	37.91	37.72	37.27	37.38	37.30	37.35
142.50	139.58	139.54	139.00	138.32	136.66	137.06	136.76	136.97
0.29	0.29	0.28	0.27	0.27	0.25	0.26	0.25	0.25
0.15	0.14	0.14	0.14	0.14	0.13	0.14	0.13	0.13

Appendix A.2

Advanced Technology Case - Without Emission Limits

Table 62. Electric Power Projections for BSW Region
10 - Southwest Power Pool

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Electricity Generating Cap... (gigawatts)													
Coal Steam.....	20.95	20.95	20.95	20.95	20.95	20.95	20.95	21.09	21.08	21.46	22.15	22.31	22.31
Other Fossil Steam.....	14.28	14.17	14.10	14.00	13.52	13.19	11.90	11.28	10.97	10.94	10.94	10.94	10.94
Combined Cycle.....	1.51	1.71	2.63	2.63	2.63	2.63	2.63	2.63	3.07	3.40	3.40	3.40	3.50
Combustion Turbine/Diesel.....	4.51	4.71	4.71	4.71	4.56	4.69	6.15	6.88	7.35	7.35	7.35	7.35	7.68
Nuclear Power.....	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Pumped Storage/Other.....	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	2.55	2.55	2.55	2.55	2.56	2.56	2.56	2.57	2.57	2.57	2.57	2.58	2.58
Total Capability.....	45.47	45.76	46.61	46.51	45.88	45.68	45.85	46.12	46.72	47.39	48.09	48.25	48.68
Cumulative Planned Additions ..													
Coal Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Fossil Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined Cycle.....	0.00	0.19	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Combustion Turbine/Diesel.....	0.00	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Nuclear Power.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pumped Storage/Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.03
Total Planned Additions.....	0.00	0.43	1.35	1.35	1.36	1.36	1.36	1.36	1.37	1.37	1.37	1.37	1.38
Cumulative Unplanned Addit. ..													
Coal Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.65	1.52	2.21	2.37	2.37
Other Fossil Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined Cycle.....	0.00	0.00	0.00	0.00	0.00	0.14	1.45	2.50	2.97	2.97	2.97	2.97	3.30
Combustion Turbine/Diesel.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nuclear Power.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pumped Storage/Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Unplanned Additions.....	0.00	0.00	0.00	0.00	0.00	0.14	1.66	2.65	4.08	5.36	6.05	6.21	6.44
Cumulative Total Additions..	0.00	0.43	1.35	1.35	1.36	1.50	3.02	4.01	5.45	6.73	7.43	7.59	8.02
Cumulative Retirements.....	0.00	0.10	0.18	0.28	0.91	1.30	2.74	3.46	4.30	4.91	4.91	4.91	4.91
Cogenerators ..													
Capability													
Coal.....	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Petroleum.....	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Natural Gas.....	0.78	0.78	0.72	0.72	0.73	0.75	0.77	0.78	0.80	0.81	0.83	0.85	0.86
Other Gaseous Fuels.....	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Renewable Sources.....	0.35	0.35	0.35	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.53
Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total.....	1.56	1.56	1.58	1.58	1.61	1.65	1.68	1.72	1.76	1.80	1.83	1.87	1.90
Electricity Demand (billion kilowatt-hours)													
Residential.....	56.25	58.25	59.98	61.49	62.89	64.20	65.49	66.31	66.97	68.09	69.35	70.40	71.49
Commercial/Other.....	53.47	55.65	57.98	59.73	61.54	63.02	64.40	65.87	67.26	68.80	70.41	71.83	73.41
Industrial.....	50.51	51.57	51.84	52.21	52.90	53.28	54.02	54.88	55.30	56.09	56.38	56.55	56.87
Transportation.....	0.66	0.67	0.69	0.72	0.81	0.90	0.99	1.07	1.14	1.21	1.28	1.36	1.43
Total Sales.....	161.10	166.15	170.30	174.15	178.14	181.41	184.90	188.13	190.67	194.19	197.43	200.14	203.19
Net Energy for Load (bil. kWh) ..													
Gross International Imports.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross International Exports.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Interregional Elec. Imp.	14.01	21.26	22.65	22.22	22.08	23.00	24.09	23.89	24.04	21.98	20.53	20.04	19.20
Gross Interregional Elec. Exp.	24.56	22.67	20.32	20.44	20.13	20.59	19.72	17.48	15.79	15.45	15.19	13.33	11.93
Purchases from cogenerators ..	3.66	3.70	3.72	3.76	3.83	3.91	3.98	4.07	4.16	4.25	4.34	4.44	4.55
Util. Generation for Customers ..	181.37	177.71	178.55	183.11	186.86	189.72	191.48	192.76	193.55	195.80	203.24	204.60	207.04
Total Net Energy for Load...	174.48	180.00	184.61	188.45	192.65	196.05	199.83	203.22	205.95	209.59	212.92	215.75	218.85
Generation by Fuel Type (billion kilowatt-hours)													
Coal.....	130.68	135.61	139.12	142.87	146.62	150.69	154.35	155.25	154.87	157.70	162.37	163.49	163.62
Petroleum.....	0.70	0.51	2.10	1.12	0.99	0.84	0.63	0.62	0.57	0.51	0.45	0.42	0.41
Natural Gas.....	34.66	27.01	22.50	24.20	24.24	23.28	21.57	21.97	23.17	25.64	25.45	25.73	28.04
Nuclear.....	9.49	9.81	9.81	9.72	9.62	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53
Pumped Storage/Other.....	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
Renewable Sources.....	3.94	4.83	5.06	5.26	5.44	5.44	5.45	5.46	5.47	5.48	5.48	5.48	5.48
Total Generation.....	181.37	177.71	178.56	183.11	186.86	189.72	191.48	192.76	193.55	195.80	203.24	204.61	207.04
Sales to Customers.....	181.37	177.71	178.55	183.11	186.86	189.72	191.48	192.76	193.55	195.80	203.24	204.60	207.04
Generation for Own Use.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cogenerators													
Coal.....	3.32	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36
Petroleum.....	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Natural Gas.....	2.83	2.85	2.98	3.00	3.09	3.20	3.31	3.43	3.54	3.65	3.76	3.87	3.97
Other Gaseous Fuels.....	0.05	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08
Renewable Sources.....	2.24	2.24	2.25	2.25	2.36	2.48	2.60	2.73	2.86	2.99	3.11	3.24	3.35
Other.....	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total.....	8.64	8.70	8.87	8.89	9.10	9.33	9.56	9.81	10.05	10.30	10.52	10.76	10.98
Sales to Utilities.....	3.66	3.70	3.72	3.76	3.83	3.91	3.98	4.07	4.16	4.25	4.34	4.44	4.55
Generation for Own Use.....	4.98	5.01	5.15	5.13	5.27	5.42	5.58	5.74	5.90	6.05	6.18	6.32	6.43
End-Use Prices (1999 cents per kilowatt-hour)													
Residential.....	5.8	5.6	5.5	5.4	5.4	5.4	5.4	6.1	6.2	6.3	6.4	6.4	6.4
Commercial.....	6.3	6.1	6.0	6.4	6.2	6.1	6.1	6.0	6.0	6.0	5.9	5.9	5.8
Industrial.....	3.3	3.2	3.1	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Transportation.....	4.6	4.6	4.5	4.5	4.4	4.4	4.4	4.4	4.4	4.4	4.3	4.3	4.2
All Sectors Average.....	5.2	5.0	4.9	5.2	5.1	5.1	5.1	5.3	5.4	5.4	5.4	5.4	5.3
Prices by Service Category (1999 cents/kwh)													
Generation.....	2.6	2.4	2.4	2.7	2.7	2.7	2.7	2.9	2.9	3.0	3.0	3.0	3.0
Transmission.....	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
Distribution.....	2.0	2.0	2.0	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Fuel Consumption (quad. Btu) ..													
Coal.....	1.38	1.43	1.47	1.51	1.55	1.60	1.64	1.64	1.63	1.64	1.67	1.68	1.68
Natural Gas.....	0.36	0.27	0.22	0.24	0.24	0.23	0.21	0.22	0.22	0.23	0.23	0.24	0.25
Oil.....	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Total.....	1.74	1.71	1.71	1.76	1.80	1.83	1.85	1.86	1.85	1.88	1.91	1.92	1.94
Emissions (million short tons) ..													
Total Carbon.....	45.84	45.71	46.25	47.36	48.45	49.49	50.31	50.55	50.17	50.69	51.52	51.73	52.01
Carbon Dioxide.....	168.10	167.59	169.59	173.67	177.64	181.45	184.47	185.36	183.97	185.85	188.92	189.68	190.71
Sulfur Dioxide.....	0.41	0.40	0.42	0.44	0.45	0.47	0.48	0.48	0.47	0.45	0.45	0.46	0.46
Nitrogen Oxide.....	0.32	0.30	0.30	0.30	0.31	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.32

Appendix A.2

Advanced Technology Case - Without Emission Limits

2012	2013	2014	2015	2016	2017	2018	2019	2020
22.31	22.31	22.31	22.31	22.31	22.31	22.31	22.31	22.31
10.94	10.94	10.94	10.94	10.94	10.94	10.94	10.94	10.94
3.94	4.12	4.41	4.82	5.29	5.79	6.32	6.80	7.22
7.73	7.79	7.97	8.19	8.50	8.62	9.02	9.27	9.63
1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.59	2.59	2.60	2.60	2.61	2.61	2.62	2.62	2.63
49.19	49.43	49.89	50.53	51.32	51.96	52.91	53.65	54.46
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07
1.38	1.39	1.39	1.40	1.40	1.41	1.41	1.42	1.42
2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.41	1.59	1.88	2.29	2.76	3.26	3.79	4.27	4.69
3.36	3.41	3.59	3.81	4.12	4.24	4.64	4.89	5.25
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.14	7.37	7.84	8.47	9.25	9.89	10.83	11.57	12.37
8.53	8.76	9.23	9.87	10.66	11.30	12.24	12.99	13.79
4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91
0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.89	0.89	0.91	0.93	0.95	0.96	0.98	1.00	1.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.55	0.57	0.59	0.61	0.63	0.64	0.66	0.68	0.70
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.94	1.97	2.01	2.04	2.08	2.12	2.15	2.18	2.22
72.55	73.63	74.63	75.88	77.07	78.42	79.69	81.12	82.35
74.81	76.04	77.13	78.28	79.32	80.39	81.31	82.24	82.97
57.47	58.04	58.78	59.45	60.14	60.73	61.29	62.11	62.91
1.50	1.56	1.63	1.67	1.67	1.66	1.65	1.64	1.62
206.32	209.27	212.18	215.29	218.20	221.16	223.94	227.11	229.85
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.01	17.72	16.97	15.05	13.43	11.93	10.57	9.83	9.04
10.69	9.72	8.60	7.72	6.48	5.12	3.92	3.05	2.81
4.65	4.77	4.89	5.02	5.15	5.28	5.42	5.56	5.70
210.04	212.23	214.79	218.81	222.13	225.27	228.28	231.40	234.72
222.02	225.00	228.05	231.16	234.23	237.37	240.35	243.74	246.65
163.81	163.92	164.14	164.18	164.25	164.36	164.28	164.31	164.41
0.41	0.41	0.40	0.39	0.37	0.38	0.36	0.33	0.33
30.83	32.91	35.24	39.22	42.48	45.49	48.59	51.69	54.89
9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53
-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
5.50	5.51	5.52	5.53	5.54	5.55	5.56	5.57	5.58
210.04	212.23	214.79	218.81	222.13	225.27	228.28	231.41	234.72
210.04	212.23	214.79	218.81	222.13	225.27	228.28	231.40	234.72
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
4.08	4.19	4.31	4.43	4.56	4.68	4.79	4.89	5.00
0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
3.47	3.61	3.73	3.86	3.98	4.11	4.22	4.34	4.46
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
11.21	11.45	11.69	11.95	12.20	12.44	12.66	12.89	13.11
4.65	4.77	4.89	5.02	5.15	5.28	5.42	5.56	5.70
6.55	6.68	6.80	6.93	7.05	7.15	7.24	7.33	7.41
6.4	6.4	6.4	6.4	6.3	6.3	6.2	6.1	6.1
5.7	5.7	5.7	5.7	5.6	5.6	5.5	5.4	5.3
3.4	3.4	3.5	3.4	3.4	3.4	3.3	3.2	3.2
4.1	4.1	4.1	4.0	4.0	3.9	3.9	3.8	3.8
5.3	5.3	5.3	5.3	5.2	5.2	5.1	5.0	5.0
2.9	2.9	3.0	3.0	2.9	2.9	2.8	2.8	2.8
0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6
1.68	1.68	1.68	1.68	1.69	1.69	1.69	1.69	1.69
0.27	0.28	0.30	0.32	0.34	0.35	0.36	0.38	0.39
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.95	1.97	1.99	2.01	2.03	2.04	2.05	2.07	2.08
52.31	52.57	52.85	53.23	53.51	53.74	53.86	53.98	54.27
191.79	192.76	193.78	195.19	196.22	197.04	197.48	197.94	198.98
0.46	0.45	0.46	0.46	0.47	0.47	0.47	0.48	0.47
0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

Appendix A.2

Advanced Technology Case - With Emission Limits

Table 62. Electric Power Projections for ERM Region
10 - Southeast Power Pool

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Electricity Generating Cap...													
(gigawatts)													
Coal Steam.....	20.95	20.95	20.95	20.95	20.95	20.95	20.95	19.47	19.35	18.20	18.20	18.16	18.07
Other Fossil Steam.....	14.28	14.17	14.10	14.00	13.44	12.42	11.13	10.51	10.20	10.17	10.17	10.17	10.17
Combined Cycle.....	1.51	1.71	2.63	2.63	2.63	4.99	6.85	6.85	6.99	9.45	9.45	9.45	9.45
Combustion Turbine/Diesel.....	6.07	6.31	6.31	6.27	6.11	6.11	6.05	5.94	6.72	6.72	6.72	6.72	6.72
Nuclear Power.....	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Pumped Storage/Other.....	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	2.35	2.35	2.35	2.35	2.36	2.36	2.61	2.62	2.62	2.62	2.62	2.63	2.63
Total Capability.....	47.03	47.36	48.20	48.07	47.35	48.30	49.24	47.46	47.55	48.83	48.83	48.80	48.72
Cumulative Planned Additions ..													
Coal Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Fossil Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined Cycle.....	0.00	0.19	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Combustion Turbine/Diesel.....	0.00	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Nuclear Power.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pumped Storage/Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.03
Total Planned Additions.....	0.00	0.43	1.35	1.35	1.36	1.36	1.36	1.36	1.37	1.37	1.37	1.37	1.38
Cumulative Unplanned Addit. ..													
Coal Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Fossil Steam.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined Cycle.....	0.00	0.00	0.00	0.00	0.00	1.97	4.22	4.22	4.36	6.92	6.92	6.92	6.92
Combustion Turbine/Diesel.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.78	0.78	0.78	0.78
Nuclear Power.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pumped Storage/Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Cells.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renewable Sources.....	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total Unplanned Additions.....	0.00	0.00	0.00	0.00	0.00	1.97	4.27	4.27	5.20	7.75	7.75	7.75	7.75
Cumulative Total Additions...	0.00	0.43	1.35	1.35	1.36	1.33	5.63	5.64	6.57	9.12	9.13	9.13	9.13
Cumulative Retirements.....													
0.00	0.10	0.18	0.32	1.03	2.11	3.54	5.35	6.18	7.46	7.46	7.50	7.58	
Cogenerators ..													
Capability													
Coal.....	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Petroleum.....	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Natural Gas.....	0.70	0.70	0.72	0.72	0.75	0.78	0.82	0.86	0.90	0.94	0.98	1.03	1.08
Other Gaseous Fuels.....	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Renewable Sources.....	0.28	0.35	0.35	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.53
Other.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total.....	1.56	1.56	1.58	1.58	1.63	1.68	1.74	1.80	1.86	1.93	1.99	2.06	2.12
Electricity Demand													
(billion kilowatt-hours)													
Residential.....	56.25	58.25	59.98	60.45	61.45	62.79	63.80	63.26	62.54	63.84	65.02	65.69	66.51
Commercial/Other.....	53.67	55.65	57.54	57.84	59.23	60.87	62.07	62.84	63.12	64.74	66.14	67.08	68.33
Industrial.....	50.51	51.57	51.86	51.71	51.82	52.06	52.24	52.46	52.67	52.96	52.92	52.80	52.44
Transportation.....	0.66	0.67	0.69	0.72	0.81	0.90	0.99	1.07	1.14	1.21	1.28	1.36	1.43
Total Sales.....	161.10	166.13	170.52	170.72	173.32	176.63	179.11	179.63	179.48	182.76	185.36	186.93	188.70
Net Energy for Load (bil.kwh) ..													
Gross International Imports.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross International Exports.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Interregional Elec. Imp. ..	13.97	21.27	22.74	19.12	17.95	18.89	15.94	18.39	17.34	16.08	16.65	14.53	13.17
Gross Interregional Elec. Exp. ..	24.24	21.23	20.12	21.71	20.09	20.39	17.97	13.41	12.63	13.41	13.49	12.22	10.98
Purchases from cogenerators ..	3.67	3.70	3.72	3.69	3.76	3.83	3.91	4.02	4.26	4.38	4.51	4.68	4.79
Util. Generation for Customers ..	181.09	176.29	178.30	183.46	185.67	188.37	191.53	184.99	184.87	190.37	192.25	194.55	195.99
Total Net Energy for Load...	174.49	180.03	184.63	184.57	187.28	190.71	193.42	193.99	193.84	197.23	199.93	201.51	203.37
Generation by Fuel Type													
(billion kilowatt-hours)													
Coal.....	130.83	135.54	139.15	139.46	140.93	140.48	133.40	120.84	109.85	107.24	109.80	109.05	105.66
Petroleum.....	0.68	0.49	2.14	0.85	0.60	0.32	0.17	0.25	0.51	0.19	0.17	0.22	0.24
Natural Gas.....	34.58	25.68	22.39	24.97	23.99	26.87	37.90	42.55	53.64	62.21	61.39	64.43	69.39
Nuclear.....	9.44	9.81	9.81	9.72	9.62	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53
Pumped Storage/Other.....	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
Renewable Sources.....	5.63	4.83	4.85	8.52	10.57	11.21	10.58	11.86	11.40	11.24	11.41	11.37	11.21
Total Generation.....	181.10	176.29	178.30	183.46	185.67	188.37	191.53	184.99	184.88	190.37	192.26	194.55	195.99
Sales to Customers.....	181.09	176.29	178.30	183.46	185.66	188.37	191.53	184.99	184.87	190.37	192.26	194.55	195.99
Generation for Own Use.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cogenerators													
Coal.....	3.33	3.36	3.36	3.29	3.27	3.26	3.24	3.24	3.36	3.36	3.36	3.36	3.36
Petroleum.....	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Natural Gas.....	2.83	2.85	2.99	3.00	3.22	3.44	3.66	3.93	4.24	4.53	4.81	5.13	5.47
Other Gaseous Fuels.....	0.05	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08
Renewable Sources.....	2.24	2.24	2.25	2.25	2.35	2.47	2.59	2.72	2.85	2.98	3.11	3.23	3.35
Other.....	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total.....	8.65	8.70	8.87	8.82	9.13	9.45	9.78	10.17	10.74	11.16	11.56	12.01	12.46
Sales to Utilities.....	3.67	3.70	3.72	3.69	3.76	3.83	3.91	4.02	4.26	4.38	4.51	4.65	4.79
Generation for Own Use.....	4.98	5.01	5.15	5.13	5.37	5.62	5.87	6.16	6.48	6.78	7.06	7.37	7.67
End-Use Prices													
(1999 cents per kilowatt-hour)													
Residential.....	5.8	5.7	5.6	5.6	5.6	5.5	5.5	7.9	8.7	8.3	8.2	8.3	8.3
Commercial.....	6.4	6.2	6.1	6.3	6.3	7.8	7.7	8.1	8.9	8.4	8.2	8.1	8.0
Industrial.....	3.4	3.3	3.2	4.4	4.6	4.4	4.7	4.7	5.3	5.0	4.9	5.0	5.0
Transportation.....	4.6	4.6	4.6	4.7	4.8	4.8	4.9	4.8	5.1	5.1	5.1	5.1	5.1
All Sectors Average.....	5.2	5.1	5.0	6.1	6.2	6.0	6.0	7.0	7.7	7.3	7.2	7.3	7.2
Prices by Service Category													
(1999 cents/kwh)													
Generation.....	2.7	2.5	2.5	3.6	3.7	3.5	3.5	4.5	5.2	4.8	4.7	4.8	4.7
Transmission.....	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7
Distribution.....	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.8
Fuel Consumption (quad. Btu) ..													
Coal.....	1.38	1.43	1.47	1.47	1.49	1.48	1.41	1.27	1.15	1.13	1.15	1.14	1.11
Natural Gas.....	0.35	0.26	0.22	0.24	0.23	0.21	0.27	0.30	0.39	0.42	0.42	0.44	0.48
Oil.....	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total.....	1.74	1.69	1.71	1.72	1.72	1.70	1.67	1.58	1.55	1.55	1.57	1.59	1.59
Emissions(million short tons) ..													
Total Carbon.....	45.85	45.44	45.99	45.97	45.99	45.54	44.19	41.05	38.91	38.50	39.23	39.52	39.13
Carbon Dioxide.....	168.12	166.62	168.64	168.57	168.63	166.97	162.04	150.51	142.88	141.17	143.85	144.90	143.47
Sulfur Dioxide.....	0.42	0.40	0.43	0.45	0.46	0.46	0.42	0.37	0.41	0.47	0.40	0.32	0.31
Nitrogen Oxide.....	0.32	0.29	0.30	0.30	0.30	0.29	0.26	0.24	0.17	0.17	0.17	0.17	0.17

Appendix A.2

Advanced Technology Case - With Emission Limits

2012	2013	2014	2015	2016	2017	2018	2019	2020
18.07	18.07	17.99	17.99	17.99	17.99	17.99	17.99	17.99
10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17
10.24	10.24	10.24	10.58	11.15	11.15	12.31	12.31	12.62
6.72	6.72	6.72	6.72	6.72	6.72	6.72	6.72	6.72
1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.68	2.68	2.69	2.71	2.74	2.75	2.81	2.81	2.82
49.55	49.56	49.48	49.84	50.44	50.44	51.67	51.67	51.99
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07
1.38	1.39	1.39	1.40	1.40	1.41	1.41	1.42	1.42
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.71	7.71	7.71	8.05	8.62	8.62	9.78	9.78	10.09
0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.09	0.09	0.09	0.11	0.14	0.14	0.19	0.19	0.19
8.58	8.58	8.58	8.94	9.53	9.53	10.76	10.76	11.07
9.97	9.97	9.98	10.34	10.94	10.94	12.17	12.18	12.49
7.58	7.58	7.67	7.67	7.67	7.67	7.67	7.67	7.67
0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1.13	1.19	1.24	1.30	1.36	1.41	1.47	1.52	1.57
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.55	0.57	0.59	0.61	0.62	0.64	0.66	0.68	0.70
0.08	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2.19	2.27	2.34	2.42	2.49	2.57	2.64	2.71	2.78
67.73	68.48	69.62	70.72	72.19	73.33	74.78	75.95	77.22
69.67	70.34	71.64	72.54	73.61	74.22	75.19	75.75	76.34
52.82	52.78	52.99	53.30	53.73	54.00	54.37	54.79	55.27
1.50	1.56	1.63	1.67	1.67	1.66	1.65	1.64	1.62
191.71	193.36	195.88	198.23	201.19	203.11	206.00	208.13	210.45
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.03	12.14	11.38	10.65	11.75	8.27	6.91	7.90	8.14
9.66	8.04	7.13	5.90	5.28	3.26	2.47	1.85	1.30
4.94	5.11	5.28	5.47	5.65	5.84	6.03	6.23	6.44
199.13	198.85	201.06	202.73	204.02	207.31	210.74	211.24	212.74
206.44	208.06	210.89	212.95	216.13	218.16	221.21	223.52	226.01
103.92	105.17	105.57	104.36	105.20	102.69	100.60	102.53	101.95
0.24	0.21	0.26	0.24	0.18	0.25	0.22	0.19	0.17
74.24	72.66	74.39	77.29	77.66	85.51	88.98	87.47	89.58
9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53	9.53
-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
11.25	11.32	11.35	11.36	11.49	11.37	11.46	11.57	11.55
199.13	198.85	201.06	202.73	204.02	207.31	210.74	211.24	212.74
199.13	198.85	201.06	202.73	204.02	207.31	210.74	211.24	212.74
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.36	3.36	3.36	3.35	3.35	3.35	3.35	3.35	3.35
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
5.81	6.18	6.55	6.95	7.33	7.71	8.06	8.42	8.76
0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
3.47	3.40	3.72	3.85	3.97	4.09	4.21	4.33	4.45
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
12.92	13.43	13.92	14.45	14.95	15.46	15.93	16.40	16.87
4.94	5.11	5.28	5.47	5.65	5.84	6.03	6.23	6.44
7.98	8.32	8.64	8.98	9.30	9.62	9.89	10.17	10.44
8.0	8.0	8.0	8.0	7.8	7.9	7.6	7.6	7.5
7.7	7.7	7.6	7.6	7.3	7.4	7.1	7.0	6.9
4.8	4.9	4.8	4.8	4.6	4.7	4.5	4.5	4.4
5.0	5.0	4.9	4.9	4.7	4.7	4.6	4.5	4.4
7.0	7.0	7.0	6.9	6.7	6.8	6.6	6.5	6.4
4.5	4.6	4.6	4.5	4.4	4.5	4.3	4.2	4.2
0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7
1.09	1.10	1.11	1.10	1.10	1.08	1.05	1.07	1.07
0.51	0.50	0.51	0.53	0.52	0.57	0.58	0.57	0.58
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.60	1.60	1.62	1.63	1.62	1.65	1.64	1.65	1.65
39.03	39.22	39.59	39.56	39.64	39.66	39.25	39.60	39.58
143.09	143.81	145.18	145.07	145.35	145.40	143.92	145.21	145.11
0.30	0.31	0.31	0.30	0.30	0.29	0.29	0.29	0.30
0.17	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.16

Appendix A.2

Reference Case – Scrubber Technology – Without Emission Limits

Table 117. National Impacts of the Clean Air Act Amendments of 1990 (CAAA90)

The Worksheet was generated by ftab
scenabs.d080301a

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Scrubber Retrofits (gigawatts)...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOX Controls									
Combustion.....	0.00	0.00	0.00	1.02	1.53	2.53	2.53	2.53	2.70
SCR Post-combustion.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MCR Post-combustion.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
ACI Controls									
Spray Cooling.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Supplemental Fabric Filter....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A.2

Reference Case – Scrubber Technology – Without Emission Limits

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.70	2.72	2.72	2.72	2.72	2.72	2.76	2.76	2.76	2.76	2.76	2.76	2.76
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A.2

Reference Case – Scrubber Technology – With Emission Limits

Table 117. National Impacts of the Clean Air Act Amendments of 1990 (CAAA90)

The Worksheet was generated by ftab
scensem.d081601a

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Scrubber Retrofits (gigawatts)...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOX Controls									
Combustion.....	0.00	0.00	0.00	2.06	2.59	2.59	2.77	2.99	3.45
SCR Post-combustion.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.24
NCR Post-combustion.....	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.98
ACI Controls									
Spray Cooling.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.09
Supplemental Fabric Filter....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	7.66

Appendix A.2

Reference Case – Scrubber Technology – With Emission Limits

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45
5.24	5.24	5.24	5.24	5.24	5.24	5.24	5.24	5.24	5.24	5.24	5.24	5.24
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
3.52	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
8.08	9.56	9.56	9.56	9.56	9.56	9.56	9.56	9.56	9.56	9.56	9.56	9.56

Appendix A.2

Advanced Technology Case – Scrubber Technology – Without Emission Limits

Table 117. National Impacts of the Clean Air Act Amendments of 1990 (CAAA90)

The Worksheet was generated by ftab
scenbbs.d080301a

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Scrubber Retrofits (gigawatts)...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOX Controls									
Combustion.....	0.00	0.00	0.00	1.02	1.02	2.53	2.53	2.53	2.70
SCR Post-combustion.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NCR Post-combustion.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
ACI Controls									
Spray Cooling.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Supplemental Fabric Filter....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A.2

Advanced Technology Case – Scrubber Technology – Without Emission Limits

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.70	2.72	2.72	2.72	2.72	2.72	2.76	2.76	2.76	2.76	2.76	2.76	2.76
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A.2

Advanced Technology Case – Scrubber Technology – With Emission Limits

Table 117. National Impacts of the Clean Air Act Amendments of 1990 (CAAA90)

The Worksheet was generated by ftab
scenbem.d081701a

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Scrubber Retrofits (gigawatts)...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOX Controls									
Combustion.....	0.00	0.00	0.00	1.57	1.57	1.57	2.09	2.10	2.72
SCR Post-combustion.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.05
NCR Post-combustion.....	0.00	0.00	0.00	0.03	0.03	0.04	0.04	0.04	2.06
ACI Controls									
Spray Cooling.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.19
Supplemental Fabric Filter....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.47

Appendix A.2

Advanced Technology Case – Scrubber Technology – With Emission Limits

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.94	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35
4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05
2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06
10.03	10.03	10.03	10.03	10.03	10.03	10.03	10.03	10.03	10.03	10.03	10.03	10.03
14.47	14.47	14.47	14.47	14.47	14.47	14.47	14.47	14.47	14.47	14.47	14.47	14.47



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